PMAC780H-Pro Power Quality Analyzer

User Manual

V1.0

ZHUPAI PILOT TECHNOLOGY CO.,LTD

Security and Precautions

Danger and Warning

This equipment must only be installed by professionals.

The manufacturer shall not bear any responsibility for malfunctions caused by failure to follow the instructions in this manual.

Precautionary Notes

After unpacking this instrument, please read this manual carefully and ensure installation and setup are performed according to the operating methods described.

This device must not be installed or have its wiring altered while energized. Before performing any wiring, the working power supply must be disconnected.

Before powering on the device, all mechanical components, doors, and covers should be restored to their original positions.

The device should be supplied with the correct rated voltage during use; the rated operating voltage must not be exceeded.

This manual is not intended to cover all details or variations of the device, nor can it provide for every circumstance regarding installation, operation, and maintenance. Please contact our company promptly if you encounter special problems.

Failure to observe these precautions may cause serious injury!

We have checked the content of this manual regarding the description of hardware and software for consistency. Since it is impossible to completely eliminate errors, we cannot guarantee full consistency. The data in this manual will be reviewed periodically, and necessary revisions will be made in new editions. Suggestions for modifications are welcome. Changes in future editions will not be announced separately.

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Chapter 1 Overview

PMAC780H-Pro is a new generation Power Quality Analyzer independently developed by ZHUHAI PILOT Technology Co., Ltd, which has high-precision measurement and metering functions, timing recording and time-of-use billing functions; rich power quality monitoring functions that comply with the latest seven national standards for power quality and the national standard for general requirements of power quality monitoring equipment. It integrates harmonic analysis, unbalance measurement, flicker monitoring, voltage fluctuation/voltage swell/sag and short interruption recording, voltage rapid change capture, inrush current, signal voltage, high-order harmonics, transient waveform capture, sudden change, event recording, real-time quantity recording and other functions, meeting the Class A standard for power quality monitoring; accurate fault diagnosis function: for local abnormalities or local faults in power supply and consumption systems, it accurately records a large amount of waveform information and event information, sensitively identifies and accurately judges potential, transient or continuous local faults, ensuring the safe and reliable operation of users' power supply and consumption systems.

PMAC780H-Pro is equipped with 4 independent voltage sampling channels and 4 independent current sampling channels, with 1024 sampling points per cycle per channel. It boasts excellent high measurement accuracy, supports precision measurement of all electrical quantities, has large built-in storage capacity, strong data persistence capability, elegant appearance design, and combines excellent performance with aesthetic appearance.

The basic functions are as follows:

Function	Description
Measuring Channels	4-channel Voltage and 4-channel Current
Basic Measurement	Voltage, Current
	Active/Reactive/Apparent Power

	Power Factor
	Inductive/Capacitive
	Frequency
Energy Metering	Full-wave Energy
	Fundamental Wave Energy
	Harmonic Energy(2~63rd order)
	Tariff Energy
	Quadrant Energy
Demand Function	Real-time Demand(Sliding Demand/Fixed Window Demand)
	Predicted Demand(Sliding Demand/Fixed Window Demand)
	Demand Maximum/Minimum(Current Max/Min/Last Max/Min)
Time-of-use Tariff Function	
Max/Min Function	Support 4 groups of maximum values and 4 groups of minimum values
Power Quality Analysis	Waveform Sampling Rate(1024 points/cycle)
	Harmonics(2~63rd order)
	Inter-harmonics(2~63rd order)
	High-order Harmonics(2k~9k)
	Voltage Deviation
	Frequency Deviation
	Unbalance/Sequence Components
	Grid Signal Voltage
	Voltage Fluctuation
	Flicker Analysis
	Voltage Swell/Sag and Interruption Monitoring
	Sag Source Location
	Sudden Change

	Transient Capture(20 μs)
	Voltage Rapid Change
	Inrush Current
Marking Function	Transient Event Data Marking
Voltage Statistical Evaluation	ITIC Curve
	SEMIF47 Curve
Statistical Evaluation Record	PQDIF
	EN50160
Overlimit Monitoring and Control	Normal Setting Overlimit/High-speed Overlimit (ms-level, s-level,64 groups)
Data and Event Recording	Max/Min Record
	Real-time Quantity Timing Record
	2048 entries Monitoring Events (1ms)
	2048 entries Operation Records (1ms)
	Event Counting
	Waveform Recording(Up to 256 recordsRecording modes: 1: 1024 points/cycle @ 200 cycles; 2: 512 points/cycle @ 400 cycles; 3: 256 points/cycle @ 800 cycles; 4: 128 points/cycle @ 1600 cycles;Adopts Comtrade file format)
	Daily/Monthly/Yearly Historical Energy
Display	LCD Display(Color Screen)
	Resolution 640*480
	Real-time waveform display on device interface and web
I/O	Optional 8 active digital input(external 110/220Vdc power supply) or passive digital input(internal 24Vdc power supply provided),and can be configured as pulse counting
	4 Relay Output (RO)

	2 Digital Output (DO)
Communication	2xRS485Communication ports, ModbusRTU protocol (Modbus RTU, Gateway)
	2 Ethernet Port (10/100M adaptive),ModbusTCP; IEC-61850 protocol
Time Synchronization	IRIG-B Code Time Synchronization
	SNTP Time Synchronization
	Modbus Time Synchronization
Web Service	Supports http/https
Waveform Recording	Communication Manual Recording
	Timing Recording
	Fault Recording

Chapter 2 Product Selection

The complete model specification of PMAC780H-Pro and the meaning of each code are as follows:

PMAC780H-①-②-③	
① Function Selection (Mandatory, non-combinable)	
Pro	9K Hz high-order harmonic function, WEB, 32G storage capacity, B code PPS NTP modbus time synchronization, dual network port function, demo mode, 8 tariffs and other functions
Pro DC	DC 24V power supply, 9K Hz high-order harmonic function, WEB, 32G storage capacity, B code PPS NTP modbus time synchronization, dual network port function, demo mode, 8 tariffs and other functions
② Rated Voltage and Current (Mandatory, non-combinable)	
V1	3*220/380V,5A
V2	3*220/380V,1A
V3	3*57.7/100V,5A
V4	3*57.7/100V,1A
V5	3*400/690V,5A
V6	3*400/690V,1A
③ Digital Quantity Type (Mandatory, non-combinable)	
SW	DC 110V external active digital input
SW2	DC 220V external active digital input
SD	External passive digital input

Chapter 3 Installation and Wiring

3.1 Operating Environment

Mounting Hole Size (mm)	138.00×138.00（＋0.80）
Overall Dimensions (mm)	144.00×144.00×153.4 (Length×Width×Thickness)
IP	Operation Panel: IP52; Side and Rear: IP30
Measuring Mode	Star, Delta
Operating Temperature	-25℃~+70℃
Storage Temperature	-40℃~+85℃
Altitude	⩽4000m
Relative Humidity	5%~95%, non-condensing
Usage environment	Indoor
Pollution degree	PD2

3.2 Outline Dimensions and Installation Diagram

Unit: mm

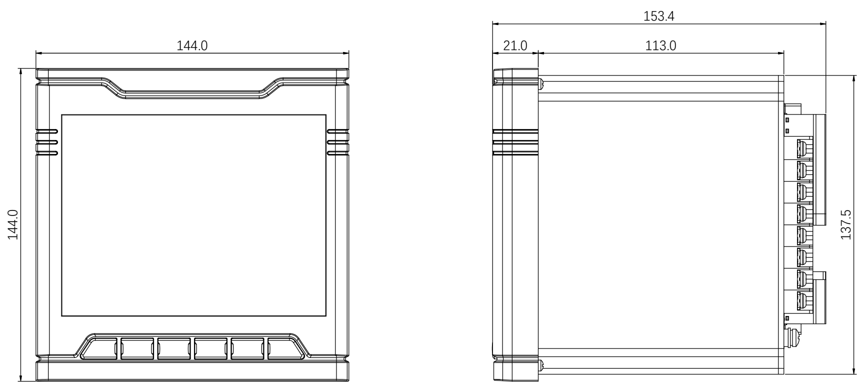


Figure 1 Product Outline Dimension Diagram

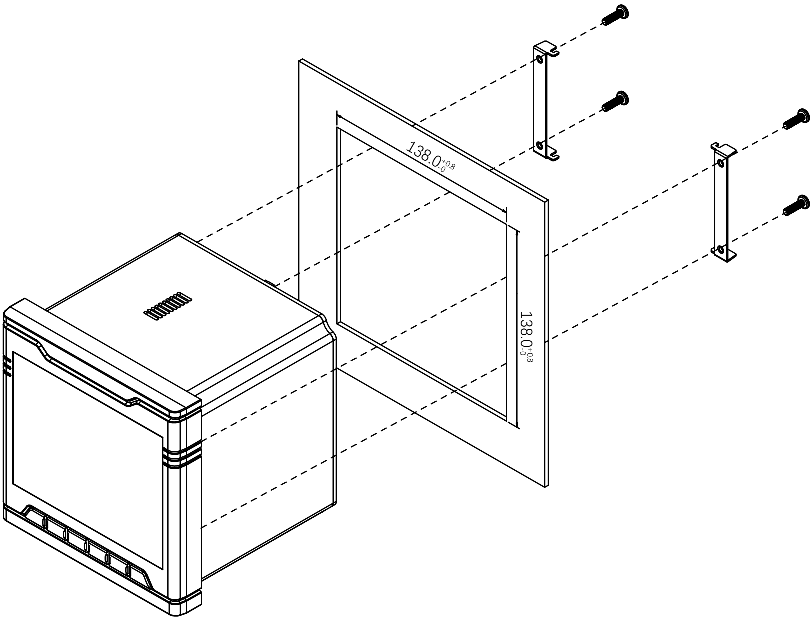


Figure 2 产品安装示意图

3.3 Back Panel Terminal Diagram

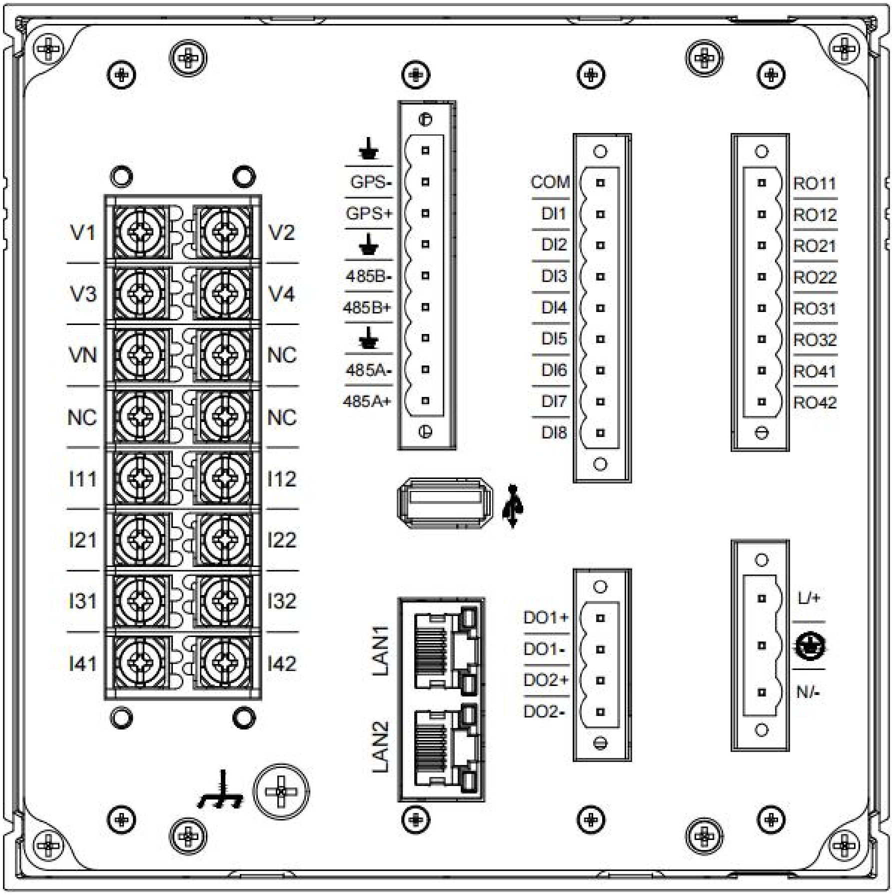


Figure 3 Back Panel Terminal Diagram

No.	Symbol	Definition
1	N/+	AC 220V live line or DC 220V positive
2		AC Power Ground Terminal
3	L/-	AC 220V neutral line or DC 220V negative
4		Chassis or Rack Terminal
5	V1	Phase A Voltage

6	V2	Phase B Voltage
7	V3	Phase C Voltage
8	V4	Voltage Neutral Line
9	VN	Neutral Line
10	I11	Phase A Current Inlet
11	I12	Phase A Current Outlet
12	I21	Phase B Current Inlet
13	I22	Phase B Current Outlet
14	I31	Phase C Current Inlet
15	I32	Phase C Current Outlet
16	I41	Neutral Line Current Inlet
17	I42	Neutral Line Current Outlet
18	⏚	RS485A Shield
19	485A+	RS485A+
20	485A-	RS485A-
21	⏚	RS485B Shield
22	485B+	RS485B+
23	485B-	RS485B-
24	LAN	Network Port
25	DI1	Channel 1 Digital Input Positive
26	DI2	Channel 2 Digital Input Positive
27	DI3	Channel 3 Digital Input Positive
28	DI4	Channel 4 Digital Input Positive
29	DI5	Channel 5 Digital Input Positive
30	DI6	Channel 6 Digital Input Positive
31	DI7	Channel 7 Digital Input Positive
32	DI8	Channel 8 Digital Input Positive
33	COM	Digital Input Common Ground
34	RO11	Relay 1 Output 1
35	RO12	Relay 1 Output 2
36	RO21	Relay 2 Output 1

37	RO22	Relay 2 Output 2
38	RO31	Relay 3 Output 1
39	RO32	Relay 3 Output 2
40	RO41	Relay 4 Output 1
41	RO42	Relay 4 Output 2
42	DO1+	Digital Output 1 Positive
43	DO1-	Digital Output 1 Negative
44	DO2+	Digital Output 2 Positive
45	DO2-	Digital Output 2 Negative
46	GPS+	B Code Timing Input Positive
47	GPS+	B Code Timing Input Negative
48	⏚	B Code Timing GND
49	NC	No Connection Terminal

3.4 Wiring

3.4.1 Power Wiring

For AC system, connect the phase wire to L/+ terminal, neutral wire to N/- terminal, and ⏚ to PE terminal; for DC power supply, connect the positive pole to L/+ terminal and negative pole to N/- terminal.

3.4.2 Voltage and Current Wiring

PMAC780H-Pro provides two measuring wiring modes: star and delta.

(1) Star Wiring Mode

When the measuring line is a star system, the device's measuring mode should be set to "Star", and the wiring method is shown in the following figures:

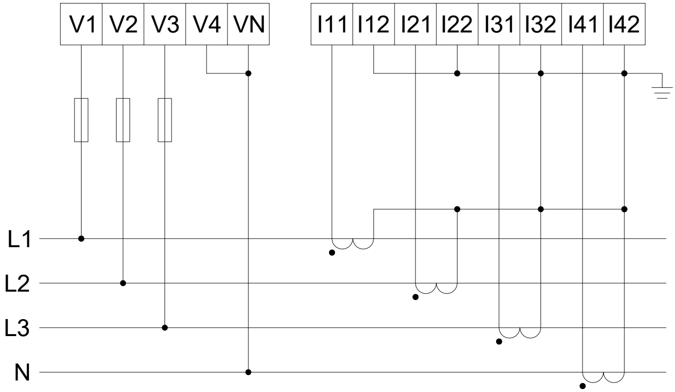


Figure 4 Low-voltage Star System

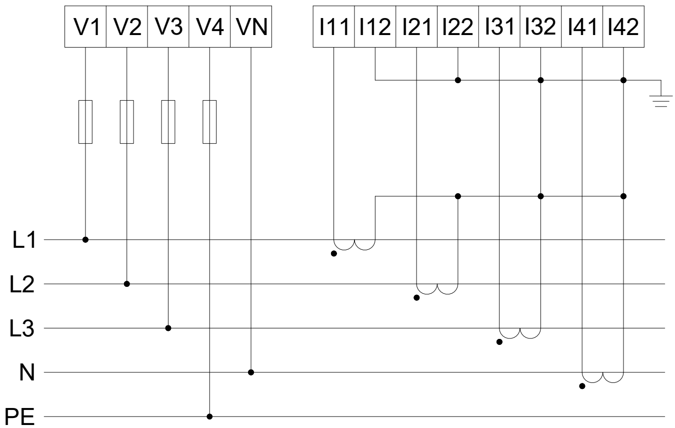


Figure 5 Low-voltage Five-wire Star System with PE

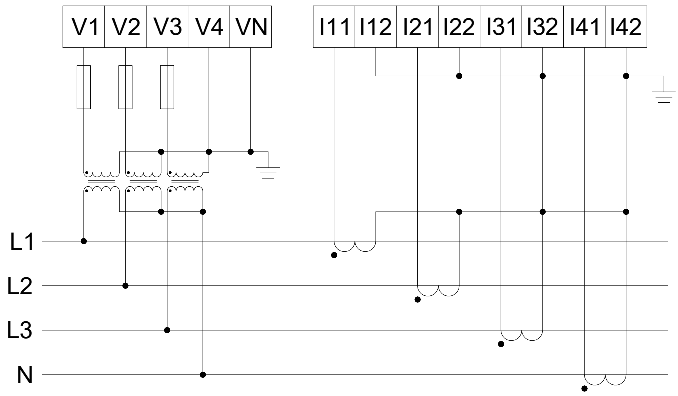


Figure 6 High-voltage Star System

Note: When V4 is not used, it needs to be short-circuited with VN; when V4 needs to be used, connect it to V4 and VN.

(2) Delta Wiring Mode

This wiring method only requires 2 PTs. The device calculates the phase B voltage value based on the measured values of phase A and phase C, and the device's measuring mode should be set to "Delta". The wiring method is shown in the following figures:

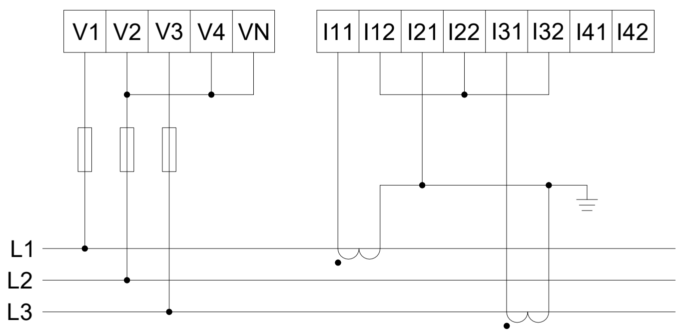


Figure 7 Low-voltage Delta System

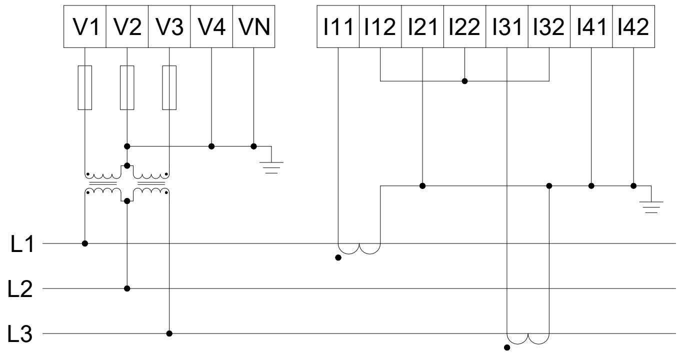


Figure 8 High-voltage Delta System

Note: When V4 is not used, it needs to be short-circuited with VN; when V4 needs to be used, connect it to V4 and VN.

3.4.3 Communication Wiring

(1) RS-485 Interface

Corresponding to interfaces RS485A (communication serial port) and RS485B (communication serial port), the terminals are marked as 485A+ (or 485B+), 485A- (or 485B-), and SHLD. It adopts a 485 dedicated isolation chip for isolation and is equipped with a protection circuit, which can prevent common-mode and differential-mode voltage interference, lightning strikes, and communication port damage caused by wrong wiring.

If the shielded twisted-pair cable is long, it is recommended to connect a resistor of approximately 120 Ω at its end to improve communication reliability.

The communication wiring is as follows:

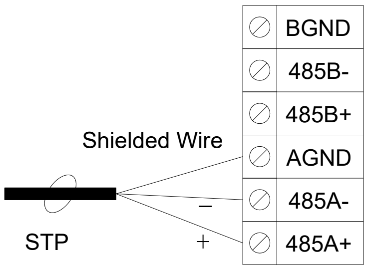


Figure 9 RS485 Wiring Diagram

(2)Ethernet communication

Ethernet communication uses an RJ-45 connector, corresponding to the LAN (10/100M) socket.

3.4.4 DI Wiring

PMAC780H-Pro provides 8 digital input, and the terminals are marked as DI1～DI8. It is suitable for monitoring status information such as circuit breaker position signals and knife switch position signals, and can be configured as ordinary digital input or pulse counting.

The device provides two specifications: external passive node input and external active node input. Users need to place an order according to actual conditions.

When the external status signal only provides position information, a feedback signal when the internal output node of the device is closed is required. The wiring method is usually as shown in the following figure:

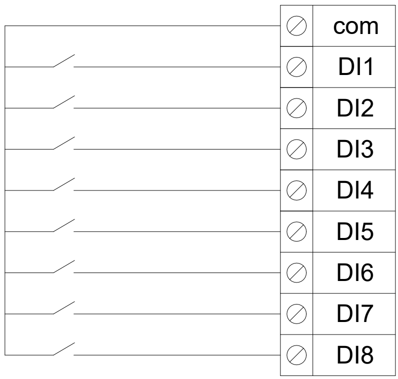


Figure 10 External Passive Digital Input Wiring Diagram

When the external status signal not only provides position information but also an additional feedback voltage signal, the external active node input method should be selected. The wiring diagram is as follows:

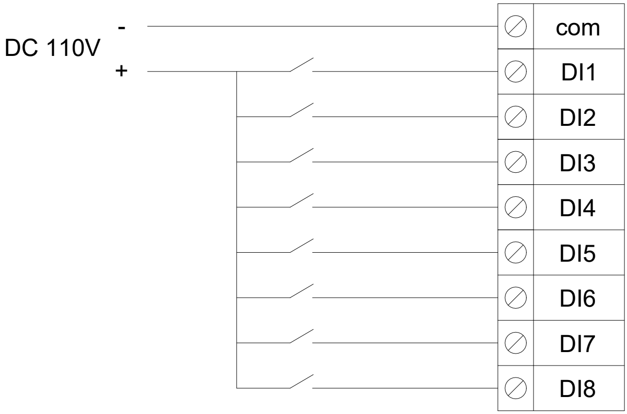


Figure 11 External Active Digital Input Wiring Diagram(SW)

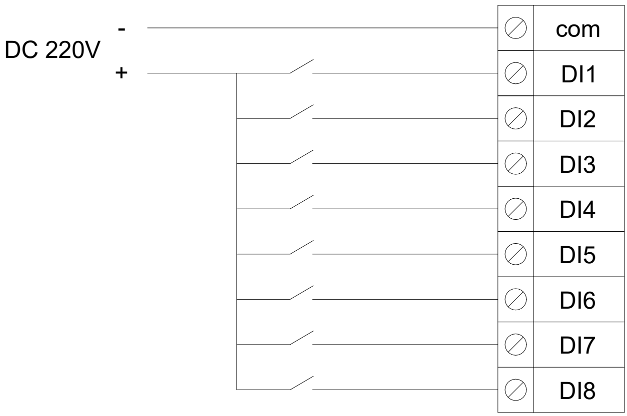


Figure 12 External Active Digital Input Wiring Diagram(SW2)

3.4.5 RO Wiring

PMAC780H-Pro provides 4 relay output, and the terminals are marked as RO1～RO4, all of which are normally open contact outputs. They can directly cut off loads of 250VAC/5A or 30VDC/5A. If used for 220V DC, the breaking capacity is 0.2A. When the load current is large, it is recommended to add an intermediate relay.

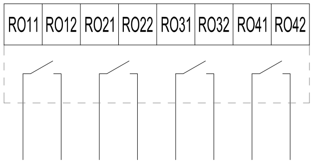


Figure 13 Relay Output Wiring Diagram

3.4.6 DO Wiring

PMAC780H-Pro provides 2 DO, and the terminals are marked as DO1~DO2. It can be configured as pulse output or digital output to cut off loads. When the load current is large, it is recommended to add an intermediate relay.

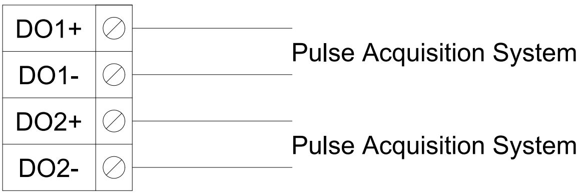


Figure 14 DO Wiring Diagram

3.4.7 USB Port

PMAC780H-Pro is equipped with one USB 2.0 interface, with a maximum transmission speed of 12Mb/s; the external power supply voltage is 5V, and the current is 0.5A.

3.5 Typical Wiring Diagrams

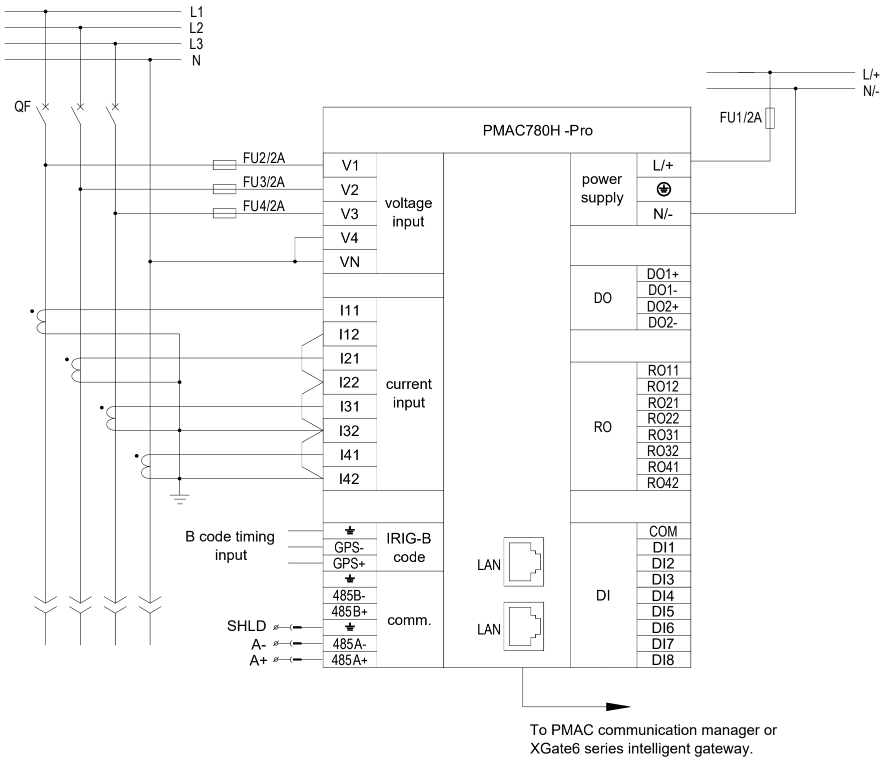


Figure 15 Low-Voltage Three-Phase Four-Wire Star System

Note: When V4 is not in use, short-circuit it with VN.

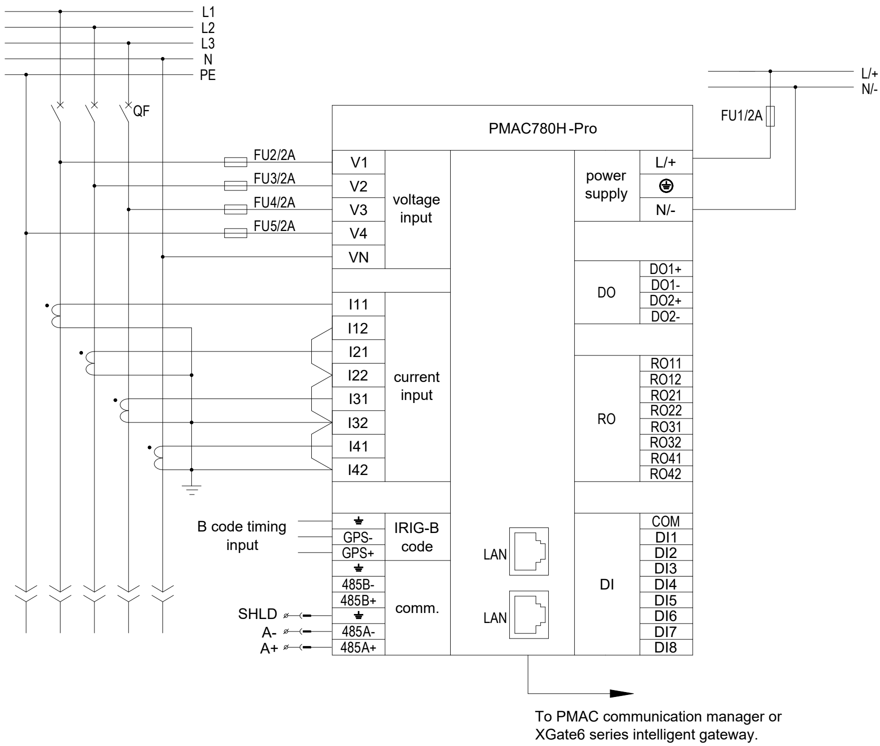


Figure 16 Low-Voltage Five-Wire Star System with PE

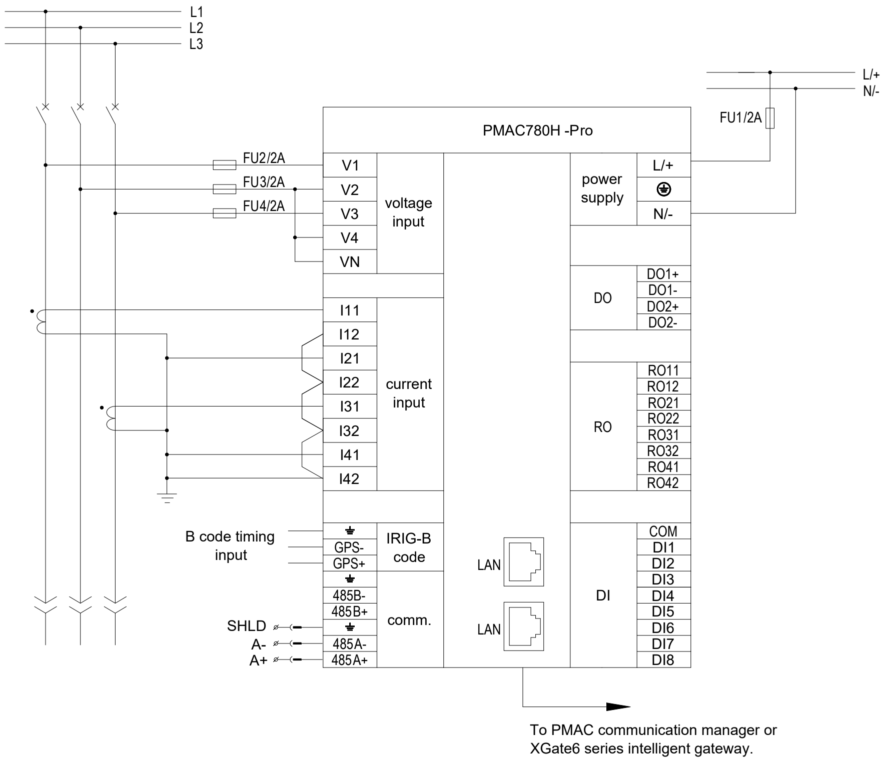


Figure 17 Low-Voltage Three-Phase Three-Wire Delta System

Note: When V4 is not in use, short-circuit it with VN.

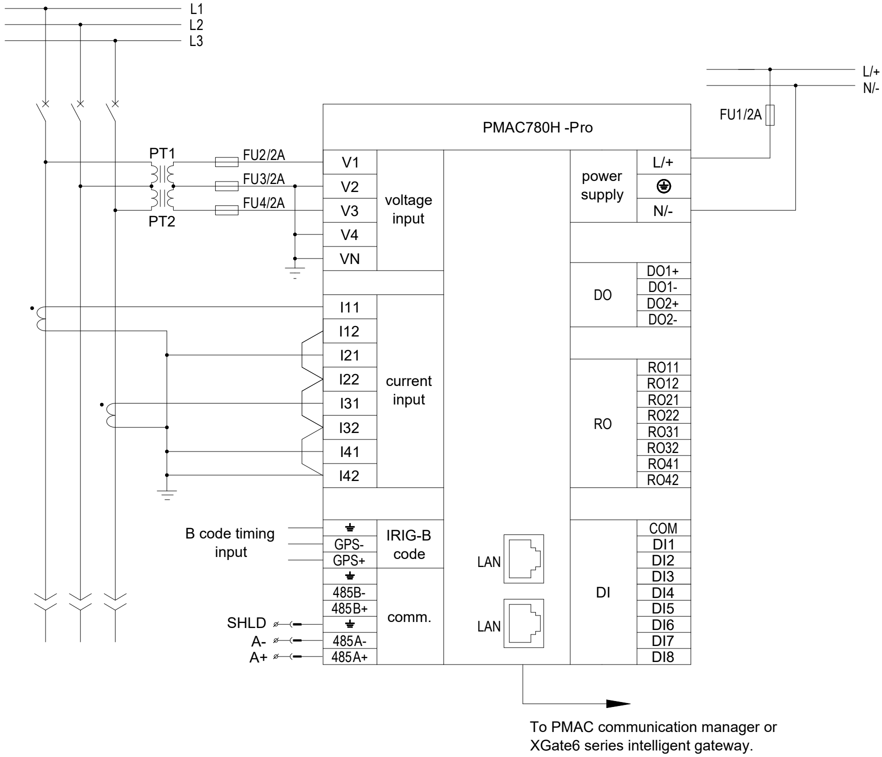


Figure 18 High-Voltage Three-Phase Three-Wire Delta System

Note: When V4 is not in use, short-circuit it with VN.

Chapter 4 Function Introduction

4.1 Measurement Functions

4.1.1 Measurement Parameters

The real-time data measurement function of PMAC780H-Pro includes basic measurement functions. Data from the basic measurement functions can be read via display, web interface, or communication. The basic measurement data includes the following:

Table 4-1 Basic Measurement Data

Type	Phase A/B/C	Total	Average	Zero Sequence	Update Cycle
Phase Voltage	√		√	√	50cyc@50Hz 60cyc@60Hz
Line Voltage	√		√		
Current	√		√	√	
Active Power	√	√			
Reactive Power	√	√			
Apparent Power	√	√			
Power Factor	√	√			
Frequency	√				10s

4.1.2 Frequency Measurement

The frequency measurement accuracy of the device is ±0.003Hz. When the rated frequency is 50Hz, the accuracy range is 42Hz to 58Hz; when the rated frequency is 60Hz, the accuracy range is 50Hz to 70Hz. It can realize online monitoring of power system frequency, and over-limit alarm and recording can be set simultaneously. During measurement, if the wiring mode is three-phase four-wire, the phase A voltage is used as the reference; if the wiring mode is three-phase three-wire, the line voltage AB is used as the reference. If there is no phase A voltage or line voltage AB, the rated frequency is used.

4.1.3 Power Factor Definition Method

The power factor calculation method can be optional as IEC/IEEE/-IEEE, with the default being the IEC method.

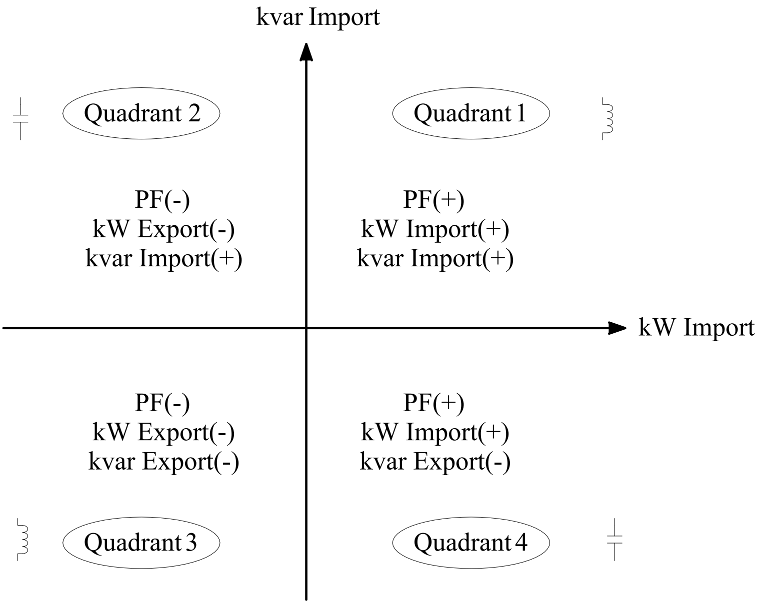


Figure 19 IEC Power Factor Definition Method

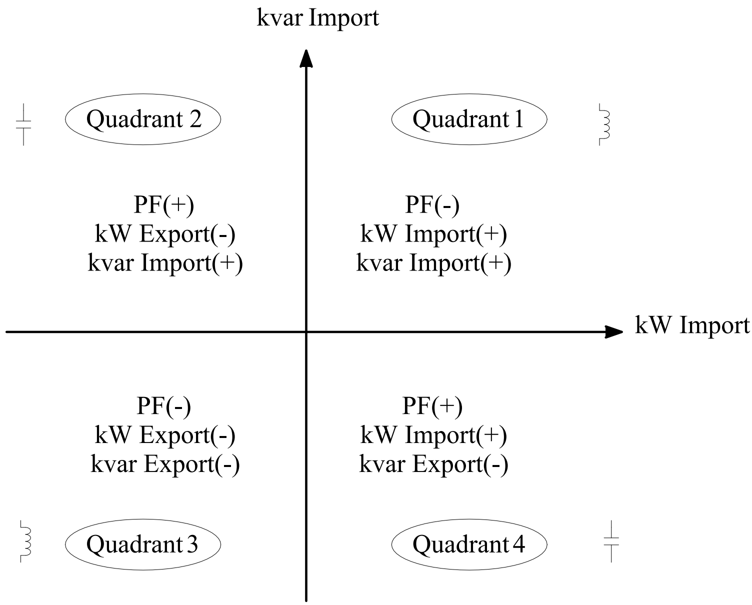


Figure 20 IEEE Power Factor Definition Method

4.1.4 Total Apparent Power Calculation Method

The total apparent power calculation method can be optionally divided into: scalar method and vector method, with the default being the scalar method.

The formula for the scalar method is as follows:

$$kVA_{total} = kVA_a + kVA_b + kVA_c$$

The formula for the vector method is as follows:

$$S^2 = P^2 + Q^2$$

4.1.5 Inductive/Capacitive

It supports phase-by-phase and total inductive/capacitive analysis, and displays the results on the LCD screen/web interface/communication.

Note: For three-phase three-wire wiring mode, there is no phase-by-phase inductive/capacitive display.

4.2 Power Quality Monitoring Functions

4.2.1 Voltage Deviation

During the operation of the power supply system, the percentage of the difference between the secondary side voltage at a certain point and the system's nominal voltage relative to the system's nominal voltage is called the voltage deviation at that point. Voltage deviation is divided into upper voltage deviation and lower voltage deviation.

(1) Upper Voltage Deviation

$$U_{over}(\%) = \frac{\sqrt{\frac{\sum_{i=1}^{n} U_{rms-over,i}^{2}}{n}} - U_{din}}{U_{din}} \times 100\%$$

Note: $U_{rms-over,i}$ is the effective value of the i-th 10 cycles.

$$U_{rms-200ms,i} < U_{din}, 则, U_{rms-over,i} = U_{din}$$

$$U_{rms-200ms,i} \geq U_{din}, 则, U_{rms-over,i} = U_{rms-200ms,i}$$

(2) Lower Voltage Deviation

$$U_{under}(\%) = \frac{U_{din} - \sqrt{\frac{\sum_{i=1}^{n} U_{rms-under,i}^{2}}{n}}}{U_{din}} \times 100\%$$

Note: $U_{rms-under,i}$ is the effective value of the i-th 10 cycles.

$$U_{rms-200ms,i} > U_{din}, 则, U_{rms-under,i} = U_{din}$$

$$U_{rms-200ms,i} \leq U_{din},则,U_{rms-under,i} = U_{rms-200ms,i}$$

PMAC780H-Pro calculates the voltage deviation in accordance with the requirements of GB/T12325-2008. The voltage measurement accuracy of the device is 0.1%, which can realize continuous monitoring and alarm recording of power system voltage deviation.

4.2.2 Frequency Deviation

Under the normal operation conditions of the power system, the difference between the actual value and the nominal value of the system frequency is called the system frequency deviation, expressed as:

Frequency Deviation = Actual Frequency － Nominal Frequency

The frequency measurement accuracy of PMAC780H-Pro is ±0.003Hz, which can realize continuous monitoring of the power system frequency. Meanwhile, over-limit alarm and recording can be set. According to standard requirements, the refresh frequency is 10s.

4.2.3 Harmonic and Interharmonic Monitoring

4.2.3.1 Harmonics and Interharmonics

PMAC780H-Pro fully complies with the IEC61000-4-7 standard. It samples 1024 points per cycle, and performs spectrum analysis with a time window of 10 cycles when the rated frequency is 50Hz, and 12 cycles when the rated frequency is 60Hz. The frequency resolution is 5Hz, and it can provide harmonics analysis data as shown in Table 4-2.

Table 4-2 Harmonics Analysis Data

	UA	UB	UC	U4	IA	IB	IC	I4
Amplitude of 2nd~63rd Harmonics	√	√	√	√	√	√	√	√
Harmonic Content Rate of 2nd~63rd Harmonics	√	√	√	√	√	√	√	√

Total Harmonic Content Rate (THD)	√	√	√	√	√	√	√	√
Total Odd Harmonic Content Rate(TOHD)	√	√	√	√	√	√	√	√
Total Even Harmonic Content Rate(TEHD)	√	√	√	√	√	√	√	√
Amplitude of 1st~63rd Interharmonics	√	√	√	√	√	√	√	√
Interharmonic Content Rate of 1st~63rd Interharmonics	√	√	√	√	√	√	√	√
Total Interharmonic Content Rate	√	√	√	√	√	√	√	√
RMS Value of DC Component	√	√	√	√	--	--	--	--
Current K-Factor	--	--	--	--	√	√	√	√
Active Power of 2nd~63rd Harmonics	√	√	√	--	√	√	√	--
Reactive Power of 2nd~63rd Harmonics	√	√	√	--	√	√	√	--
Apparent Power of 2nd~63rd Harmonics	√	√	√	--	√	√	√	--

4.2.3.2 Fundamental Wave Monitoring

PMAC780H-Pro provides users with complete fundamental wave data to meet the users' needs for analyzing the system operation status.

Table 4-3 Fundamental Wave Data

	Phase A	**Phase B**	**Phase C**	**Total**	**Neutral Line**
Voltage	√	√	√		√

Current	√	√	√		√
Active Power	√	√	√	√	
Reactive Power	√	√	√	√	
ApparentPower	√	√	√	√	

Note: When the wiring mode is three-phase four-wire, the fundamental phase voltage is displayed; when the wiring mode is three-phase three-wire, the fundamental line voltage is displayed.

4.2.3.3 K-Factor

In the technical indicators of power quality, the K-factor mainly reflects the impact of the frequency of harmonics caused by non-linear loads on transformer losses. The definition of K-factor is mainly based on the assumption that the transformer eddy current loss caused by harmonic current is proportional to the square of the harmonic order. The calculation formula is:

$$K = \frac{\sum_{h=1}^{\infty} I_h^2 h^2}{\sum_{h=1}^{\infty} I_h^2} = \frac{\sum_{h=1}^{h=h_{\max}} I_h^2 h^2}{\sum_{h=1}^{h=h_{\max}} I_h^2}$$

Note: h is the harmonic order, I_h is the effective value of the h-th harmonic current, and $h_{\max}$ is the maximum harmonic order to be considered. For the K-factor measurement data provided by the device, please refer to Table 4-2.

4.2.4 Unbalance and Sequence Component Measurement

In an ideal three-phase power supply system, the voltages and currents of phases A, B, and C have equal amplitudes and a phase difference of 120°, which is in a balanced state. When the actual system deviates from the above situation, unbalance problems and corresponding reduction in power supply efficiency occur.

PMAC780H-Pro can measure the positive sequence, negative sequence, and zero sequence amplitudes and phases of voltage and current, and calculate and analyze the voltage and current unbalance degrees, including negative sequence unbalance degree and zero sequence unbalance degree:

(1) Negative Sequence Unbalance Degree of Voltage and Current

$$u_2 = \frac{\text{Negative sequence component of voltage}}{\text{Positive sequence component of voltage}} \times 100\%$$

$$i_2 = \frac{\text{Negative sequence component of current}}{\text{Positive sequence component of current}} \times 100\%$$

(2) Zero Sequence Unbalance Degree of Voltage and Current

$$u_0 = \frac{\text{Zero sequence component of voltage}}{\text{Zero sequence component of voltage}} \times 100\%$$

$$i_0 = \frac{\text{Zero sequence component of current}}{\text{Zero sequence component of current}} \times 100\%$$

4.2.5 Voltage Fluctuation

In an ideal power system, the supply voltage should operate stably according to the specified parameters. However, in practice, it is often difficult to meet this requirement due to various external influences. A series of changes or continuous variations in the voltage effective value are called voltage fluctuation. The voltage variation value is the difference between the two extreme values of the voltage effective value, usually expressed as a percentage of the nominal voltage. The number of voltage variations per unit time is called the voltage variation frequency. The calculation formula for voltage fluctuation is as follows:

$$\text{Voltage Fluctuation } \mathrm{d} = \frac{\Delta \mathrm{U}}{\mathrm{U_N}} = \frac{\mathrm{U_{max}} - \mathrm{U_{min}}}{\mathrm{U_N}}$$

$$\text{Voltage Fluctuation Frequency } \mathrm{r} = \frac{\text{Voltage Fluctuation Times}}{\text{runtime}}$$

4.2.6 Voltage Flicker

Voltage flicker refers to the obvious periodic change of voltage in a short period of time, usually manifested as the fluctuation of voltage amplitude. This phenomenon often causes light flicker, so it is also called "light flicker". The variation amplitude of voltage flicker is usually between 2% and 10%, and the variation time is within half a cycle (about 10 milliseconds). The main determining factors of flicker are as follows:

(1) Load changes: The start or stop of high-power electrical appliances or equipment will cause an instantaneous drop or rise in the voltage in the transmission line, resulting in flicker.
(2) Line faults: Short-circuit or open-circuit faults in the transmission line may cause sudden voltage changes, leading to flicker.
(3) Power supply problems: Unstable regulation of power supply equipment such as generators or transformers may cause fluctuations in the output voltage.
(4) External interference: Severe weather conditions (such as lightning strikes, strong winds) may affect the voltage stability of the transmission line, leading to flicker.
(5) Non-linear loads: When using non-linear load equipment such as frequency converters and switching power supplies, these equipment will cause harmonic pollution in the power grid, thereby triggering voltage flicker.

Flicker measurement range: 0~20

PMAC780H-Pro calculates flicker in accordance with the recommended model of IEC61000-4-15, meeting relevant standards. It records real-time data of short-term flicker and long-term flicker, which can be read and viewed through the panel, web interface, and communication. Meanwhile, the web interface supports data export. For the configurable parameters and parameter ranges, please refer to PMAC780H-Pro-Modbus Communication Protocol.

4.2.7 Voltage Sag, Swell and Interruption

Load adjustment in the power system, normal operations (such as switching of compensation capacitors), and long-distance short-circuit faults may cause voltage sag, swell, and short-term interruption, which are the main reasons for the abnormal operation of industrial users' equipment.

Voltage swell refers to a sudden increase in voltage in a short period of time, usually manifested as a sudden rise in voltage amplitude, with a duration ranging from 10 milliseconds to several minutes.

Voltage sag refers to a sudden decrease in voltage in a short period of time, usually manifested as a sudden drop in voltage amplitude, with a duration ranging from 10 milliseconds to several minutes.

Voltage interruption refers to the voltage dropping to zero, with a duration ranging from 0.1 seconds to several minutes. Voltage interruption is a serious problem in power quality and may cause equipment to stop operating or be damaged.

Causes:

(1) Load changes: The shutdown or disconnection of high-power electrical appliances (such as the stop of a motor) may cause a sudden increase in the line voltage; the start of a motor may cause a sudden decrease in the line voltage.

(2) Power grid regulation problems: Unstable regulation of transformers or generators may cause a temporary increase or decrease in the output voltage.

(3) Line switching: Automatic switching of lines in the power grid or operation of protection equipment may cause an instantaneous increase in voltage.

(4) External interference: Lightning strikes or other transient interferences may cause a temporary increase in voltage.

(5) Line faults: Faults such as single-phase ground short circuits or other line faults may cause a temporary decrease in voltage.

(6) Switch operation: Improper operation of large-scale switchgear in the power grid may cause a temporary voltage interruption.

PMAC780H-Pro meets the national standard GB/T18481-2001 and the IEC61000-4-30 standard. It implements the following functions for voltage sag, swell, and interruption:

a. Record data such as the occurrence time, duration, and voltage residual value of each phase for each voltage transient change.

b. When each transient change exceeds the set threshold and hysteresis value, associated actions can be triggered. The action outputs include: waveform recording, real-time quantity recording, DO, and RO.

c. The event records of voltage sag, swell, and interruption are described in association with the ITIC/SEMI F47 curve.

Parameters can be set through the instrument panel, communication, and web interface. For the configurable parameters and parameter ranges, please refer to PMAC780H-Pro-Modbus Communication Protocol.

4.2.8 Sag Source Location

Voltage sag is one of the main factors affecting power quality. In recent years, the problem of voltage sag has received increasing attention. After a sag occurs, how to share responsibilities and resolve relevant disputes fairly and reasonably is also a major concern of users. To solve these problems, it is necessary to determine the location of the voltage sag source. Accurately determining the location of the voltage sag source helps to evaluate the regional power distribution system and select reasonable governance measures. Moreover, it can be used as an important basis for coordinating disputes between power departments and users in the power market environment, and at the same time, it helps to smoothly solve relevant power quality problems.

The device provides a sag source location function to determine which side of the monitoring device the disturbance causing the voltage transient occurs on. With reference to the active power flow direction, if the disturbance occurs at location A, it is called the upstream direction; if it occurs at location B, it is called the downstream direction.

When the current voltage transient starts, the sag source location function is activated. By analyzing the electrical quantity characteristics during the transient, the disturbance direction is determined, the sag source location result is analyzed, the monitoring event is recorded, and the sag source location result and reliability degree are provided.

Location results: Upstream, Downstream;

Reliability degrees of location results: Low, Medium, High.

4.2.9 Transient Capture

PMAC780H-Pro is equipped with a transient capture function, which is designed to capture and record instantaneous changes in voltage. This function can capture voltage transients shorter than 0.5 cycles, ensuring rapid response and accurate recording of power quality issues.

(1) Minimum capture time of 20 μs: The device can capture voltage transients as short as 20 microseconds, accurately recording voltage changes that are difficult to detect.

(2) Precise moment recording: Whenever a voltage transient occurs, the device records the exact moment of occurrence, facilitating subsequent analysis.

(3) Flexible triggering: When a transient is captured, multiple associated actions can be triggered, including:

  a. Waveform recording: Records the voltage waveform during the transient.

  b. DO/RO output: Triggers external devices or feedback systems through digital input/output.

4.2.10 Signal Voltage

Signal voltage refers to the voltage signal used for transmitting information or control signals in a power system. Different from the power supply voltage, the signal voltage is usually a low-level voltage with a specific frequency or waveform, which is used for communication or control between devices. Common types of signal voltage include:

(1) Control signals: Used to control the start/stop or state switching of equipment, such as PLC control signals.

(2) Measurement signals: Used to transmit parameter values measured by sensors or instruments, such as electrical signals for temperature, pressure, flow rate, etc.

(3) Communication signals: Used for data transmission between devices, such as modulated signals or digital signals.

The rationality and stability of the signal voltage directly affect the normal operation of the system and the reliability of communication. Therefore, monitoring and evaluating the quality of the signal voltage is an important link to ensure the stable operation of the power system.

In accordance with the IEC 61000-4-30 standard, PMAC780H-Pro provides a high-precision signal voltage detection function, which can real-time monitor the 3-second effective value of the three-phase signal voltage. This function supports monitoring three groups of signal voltages with different frequencies, and both the monitoring frequency and limit value can be flexibly configured through settings. Through this function, users can accurately identify and record changes in the voltage signal, ensuring that the quality of the signal voltage meets the requirements.

Parameters can be set via communication or the Web interface. For the configurable parameters and parameter ranges, please refer to PMAC780H-Pro-Modbus Communication Protocol.

4.2.11 Inrush Current

Inrush current refers to the phenomenon where the current in a circuit changes drastically in an extremely short period of time, and this change may cause damage or interference to the circuit. The main causes of inrush current are as follows:

(1) Switching operations: Sudden connection or disconnection of inductive loads (such as motors, transformers) will generate inrush current, because inductors produce high-voltage back electromotive force when the current is cut off.

(2) Short circuit: A short circuit in the circuit will cause the current to increase rapidly, generating inrush current, which is more significant especially in inductive circuits.

(3) Sudden voltage changes: Sudden changes in the power supply voltage (such as a sudden rise or drop in voltage) will cause a rapid change in current, resulting in inrush current.

(4) Equipment failure: When a fault occurs in the internal circuit of the equipment, it may lead to a sudden change in current and generate

inrush current.

In accordance with the IEC 61000-4-30 standard, PMAC780H-Pro provides an inrush current monitoring function. The monitoring of inrush current adopts the half-cycle effective value, and the calculation formula is as follows:

$$I_{hc\_rms} = \sqrt{\frac{1}{T/2}\int_0^{T/2} i^2(t)dt}$$

When the measured half-cycle RMS current is higher than the set inrush current threshold, the inrush current starts, and corresponding actions will be triggered. The action outputs include: waveform recording, real-time quantity recording, DO, and RO. The inrush current ends when the measured half-cycle RMS current is less than the set inrush current threshold minus the set hysteresis value.

Parameters can be set via communication or the Web interface. For the configurable parameters and parameter ranges, please refer to PMAC780H-Pro-Modbus Communication Protocol.

4.2.12 High-Order Harmonics

With the development trend of electrification in the new-type power system, high-order harmonics have become a new power quality problem. As the content of high-order harmonics in the system increases rapidly, it is more important to pay attention to, research, and solve this new power quality problem.

In accordance with the IEC 61000-4-30 ED3 standard, high-order harmonics generally refer to frequency signals between 2kHz and 9kHz. The specific measurement points are the amplitudes of voltage and current frequency signals at center frequency points such as 2.1kHz, 2.3kHz, 2.5kHz... 8.7kHz, and 8.9kHz. The specific display content can be viewed on the communication and Web terminals.

No.	Frequency Band	Measured Value
1	2kHz~9kHz	2.1kHz Amplitude
2	2kHz~9kHz	2.3kHz Amplitude

...	2kHz~9kHz	...
34	2kHz~9kHz	8.7kHz Amplitude
35	2kHz~9kHz	8.9kHz Amplitude

4.2.13 Sudden Change Monitoring

This device is equipped with a sudden change detection function for voltage and current, which is used to issue alarms for sudden voltage changes and sudden current changes to achieve rapid fault response. According to actual application requirements, the function activation/deactivation and trigger thresholds for voltage sudden changes and current sudden changes can be set separately. Sudden change events will record parameters such as the occurrence time, action phase, and change value.

When a sudden current/voltage change exceeding the trigger threshold is detected, the sudden change function is activated, and the duration starts to be calculated. The function ends when the sudden current/voltage change falls below the trigger threshold, and an event is generated at the same time.

4.2.14 Rapid Voltage Change

PMAC780H-Pro provides a rapid voltage change capture function. Rapid voltage change reflects the change in voltage amplitude of the voltage effective value between two steady states. Rapid voltage changes are captured based on the stable voltage tolerance, stable time, detected minimum step size, and minimum change rate (%/s). Figure 4-2 explains this. When the voltage change exceeds the threshold for voltage swell or sag, it is regarded as a swell or sag rather than a rapid voltage change. According to the definition of rapid voltage change in the Norwegian FoL, detection is performed through voltage step (Vstep), maximum voltage change (Vmax), and voltage change rate. A rapid voltage change is considered to have occurred when both the voltage step (Vstep) and voltage change rate are greater than the limit values, and the voltage change does not exceed the transient threshold. Rapid voltage change events are stored in PQ events, recording the voltage step change, change duration, and maximum voltage change (Vmax) relative to the nominal voltage.

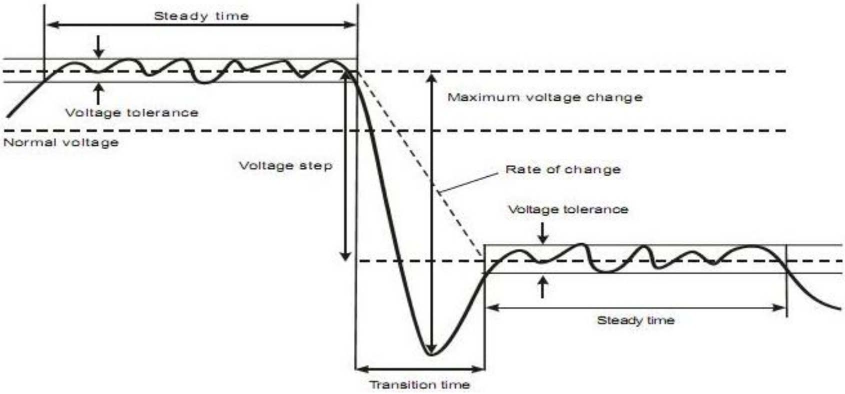


Figure 21 Rapid Voltage Change

4.2.14.1 Voltage Tolerance

It is the limit value for judging whether the voltage reaches a steady state within a certain period of time. For example, if the rated voltage is 100V, the wiring is delta-connected, and the voltage tolerance is 0.5%, the allowable fluctuation range of the line voltage in a voltage steady state is:

$$\delta U_{\max} = \delta \times U_{rate} = 100 \times 0.005 = 0.5$$

Note: $\delta U_{\max}$ is the maximum allowable voltage fluctuation value, δ is the voltage tolerance, and U_{rate} is the rated voltage.

4.2.14.2 Voltage Steady State

If the fluctuation of the voltage effective value within the steady time is within the range of the voltage tolerance, it is considered a voltage steady state. That is, within the steady time, the following condition is satisfied:

$$\frac{ABS(U_{\max} - U_{\min})}{U_{rate}} < \delta$$

Note: $U_{\max}, U_{\min}$ are the maximum and minimum values of the voltage effective value within the steady time, U_{rate} is the rated voltage, and δ is the voltage tolerance. For example, if the steady time is 5s, the rated voltage is 100V, the wiring is star-connected, the voltage tolerance is 0.5%, and the maximum and minimum voltages within the steady time are 57.25V and 57V respectively. Since the wiring is star-connected, the rated voltage should be converted to $\frac{100}{\sqrt{3}}$ ≈ 57.735V. According to the steady state judgment formula:

$$\frac{ABS(57.25-57)}{57.735} < 0.005$$

This indicates that the voltage reaches a steady state within this period of time.

4.2.14.3 Voltage Step

It is the difference between the previous steady-state voltage value and the current steady-state voltage value during a rapid voltage change. For example, in a star-connected system, if the rated voltage is 100V, the previous steady-state voltage is 57V, and the current steady-state voltage is 65V, the voltage step is:

$$\Delta U_{step} = \frac{ABS(U_{steady} - U_{laststeady})}{U_{rate}} * 100\% = \frac{ABS(57-65)}{57.735} * 100\% = 13.856\%$$

4.2.14.4 Rate of Change

It is the rate at which the voltage transitions from the previous steady state to the current steady state during a rapid voltage change. The voltage change rate is usually expressed as the ratio of the voltage step to the transition time of the rapid voltage change. For example, if the voltage step is 10% and the transition time is 1s, the voltage change rate is:

$$\frac{dU}{dt} = \frac{\Delta U_{step}}{t_{transision}} = \frac{10\%}{1s} = 10\%/s$$

Note: $\frac{dU}{dt}$ is the voltage change rate, ΔU_{step} is the voltage step, $t_{transision}$ is the transition time of the rapid voltage change.

4.2.14.5 Maximum Voltage Change

During a rapid voltage change, the percentage of the maximum change value of the voltage relative to the two previous and current steady-state voltages in the rated voltage is called the maximum voltage change. For example, in a star-connected system, if the rated voltage is 100V, the previous steady-state voltage is 57V, the current steady-state voltage is 65V, the voltage at the maximum voltage change point during the change is 69V, and the voltage at the minimum voltage change point is 52V, the maximum voltage change is:

$$\Delta U_{\max} = \frac{ABS(MAX(MAX((U_{\max change} - U_{laststeady}),(U_{\min change} - U_{laststeady})), MAX((U_{\max change} - U_{steady}),(U_{\min change} - U_{steady}))))}{U_{rate}} * 100\%$$

$$= \frac{ABS(52-65)}{57.4} * 100\% = 22.648\%$$

Note: $\Delta U_{\max}$ is the maximum voltage change, $U_{\max change}$ is the voltage at the maximum change point, U_{rate} is the rated voltage.

4.2.14.6 Rapid Voltage Change Capture Conditions

The voltage value during the rapid voltage change does not exceed the transient threshold; otherwise, it is regarded as a voltage swell or sag event.

The voltage change rate is greater than the voltage change rate parameter value.

The voltage step is greater than the voltage step parameter value / the maximum voltage change is greater than the voltage step parameter value (based on different detection modes).

A rapid voltage change can trigger actions simultaneously, and the action outputs include: disturbance recording, waveform recording, effective value recording, real-time quantity recording, DI, and RO.

4.2.15 Voltage Event Marking

PMAC780H-Pro provides a voltage event marking function. When voltage sag, swell, or interruption events occur, the device marks the measurement results of frequency, flicker, voltage amplitude, unbalance, and harmonics at the time of the voltage event.

The purpose of marking is to avoid the impact of transient events and accurately evaluate the flicker value when assessing the qualification rate of voltage fluctuation and flicker; to effectively avoid the calculation of voltage interruption events and accurately evaluate the power supply voltage amplitude when assessing the voltage qualification rate; and to effectively avoid instrument analysis and calculation errors and unreasonable measurement results and accurately evaluate the harmonic level when assessing the harmonic qualification rate.

4.2.16 Voltage Statistical Evaluation

PMAC780H-Pro provides a voltage evaluation function. It mainly refers to the measurement and evaluation of the power supply voltage quality. The specific evaluation items include voltage amplitude, frequency, harmonics, voltage negative sequence unbalance, and flicker, and it provides evaluation conclusions on whether each parameter is qualified; it also counts the number of occurrences of transients, rapid voltage changes, and transients. This evaluation function complies with the national standard GB/T 19862-2016 General Requirements for Power Quality Monitoring Equipment.

4.2.17 ITIC Curve

PMAC780H-Pro is equipped with an ITIC curve function. The ITIC curve specifies the ability of equipment to withstand power supply voltage disturbances, and its significance lies in reflecting the voltage disturbance tolerance of power equipment and evaluating the voltage disturbance level of the power supply system.

For the ITIC curve of PMAC780H-Pro device, the horizontal axis represents the duration of the voltage transient event, and the vertical axis represents the voltage percentage (relative to the nominal voltage). The upper curve represents the equipment's tolerance to voltage swells, the lower curve represents the equipment's tolerance to voltage sags, and the area between the curves represents the normal operation range. PMAC780H-Pro supports plotting and displaying a total of 100 transient events from three voltage channels on the ITIC curve.

The ITIC curve display on PMAC780H-Pro screen interface and Web interface is shown in the following figures:

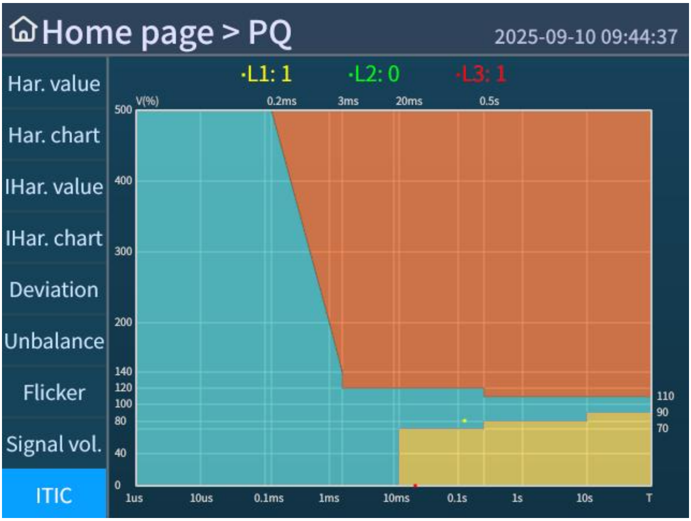


Figure 22 ITIC Curve Display on the Screen Interface

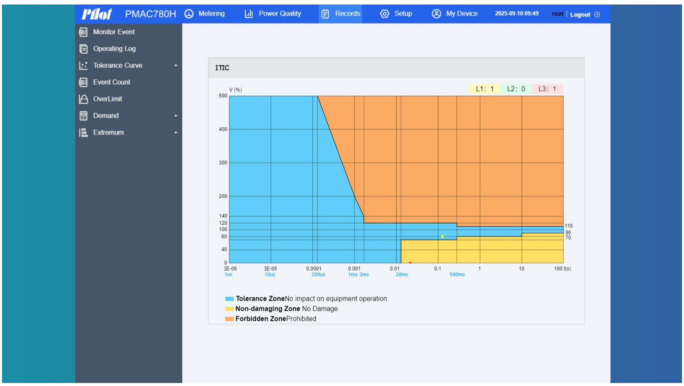


Figure 23 ITIC Curve Display on the Web Interface

4.2.18 SEMI F47 Curve

PMAC780H-Pro is equipped with a SEMI F47 curve function. The SEMI F47 curve defines the voltage sag tolerance time of equipment, and the upper area indicates that the equipment must ensure normal and continuous operation under such disturbances.

For the SEMI F47 curve of PMAC780H-Pro device, the horizontal axis represents the duration of the voltage transient event, and the vertical axis represents the voltage percentage (relative to the nominal voltage).

PMAC780H-Pro supports plotting and displaying a total of 100 transient events from three voltage channels on the SEMI F47 curve.

The SEMI F47 curve display on PMAC780H-Pro screen interface and Web interface is shown in the following figures:

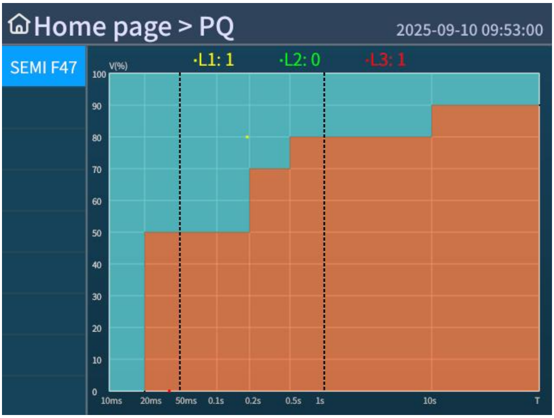


Figure 24 SEMI F47 Curve Display on the Screen Interface

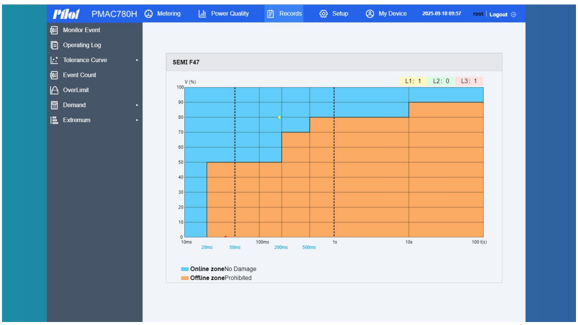


Figure 25 SEMI F47 Curve Display on the Web Interface

4.3 Energy Metering Function

4.3.1 Energy Metering Data

PMAC780H-Pro provides abundant energy metering data to facilitate users in analyzing the energy consumption of the system. The energy data provided by the device is as follows:

Table 4-4 Energy Metering Data

Parameter	Forward	Reverse	Net Value	Total
Full-Wave Active Energy	√	√	√	√
Full-Wave Reactive Energy	√	√	√	√
Full-Wave Apparent Energy				√
Fundamental Active Energy	√	√	√	√
Fundamental Reactive Energy	√	√	√	√
2nd~63rd Harmonic Active Energy	√	√		√
2nd~63rd Harmonic Reactive Energy	√	√		√

4.3.2 Energy Rollover

The maximum energy value that PMAC780H-Pro can record is 999999999.999. When the energy exceeds the maximum recordable energy, energy rollover will occur, and energy accumulation will restart.

4.3.3 Energy Pulse Output

PMAC780H-Pro supports pulse output for active energy and reactive energy.

4.4 Demand

In power systems, fees are usually charged based on users' energy consumption (in the form of active energy) and peak power consumption level (in the form of active power). Demand is defined as the average value within a certain time interval (usually 15 minutes).

4.4.1 Demand Data

The device provides real-time demand for the following data:

- Ia, Ib, Ic, I Avg
- Ua, Ub, Uc, U Avg
- Forward Pa, Pb, Pc, Total Forward P
- Reverse Pa, Pb, Pc, Total Reverse P
- Forward Qa, Qb, Qc, Total Forward Q
- Reverse Qa, Qb, Qc, Total Reverse Q
- Sa, Sb, Sc, S

Real-time demand calculation modes: Fixed demand and sliding demand (sliding demand is the default).

4.4.2 Demand Algorithm

The demand adopts the sliding cycle/fixed cycle demand algorithm, with the following configuration parameters:

- Demand calculation mode: Sliding demand
- Demand sub-cycle (sliding time): Setting range is 1 - 60 minutes
- Number of demand sub-cycles: Setting range is 1 - 15

For example, if the demand sub-cycle is set to 1 minute and the number of demand sub-cycles is 15, the demand cycle will be 1×15 = 15 minutes.

- Fixed demand: After reaching the demand cycle time, the average value within the cycle is calculated according to the fixed demand cycle time, and the demand value is output.
- Sliding demand: After the demand calculation reaches the demand cycle time, it slides according to the sub-cycle, calculates the average value within the demand cycle, and outputs the demand value.
- Predicted demand: Ordinary demand is output only at the end of the demand calculation sub-cycle. For predicted demand, the demand at the end of the demand calculation sub-cycle is predicted based on the current value. For the 780H Pro, since demand calculation is performed once per second, the predicted demand is updated once

per second. The calculation formulas for predicted demand are as follows:

$$\frac{\text{Avg Calories} \times \text{Remaining Time of Self - Cyc} + \text{Integral Value} + \text{Previous Dmd Value} \times (\text{Num. of Self - Cyc in Dmd Cyc - 1}) \times \text{Sub - Cyc Length}}{\text{Sliding Dmd Cyc}}$$

The calculation formulas for Average Calories are as follows:

$$\text{Average Calories} = \frac{\text{Avg Calories} \times (\text{Prediction Benchmark - 1}) + \text{Demand Source}}{\text{Prediction Benchmark}}$$

Note: The demand source refers to the quantity used for demand calculation. If calculating the predicted demand of active power, the demand source is the current calculated value of active power.

The formula for the prediction benchmark is as follows:

$$\text{Prediction Benchmark} = \frac{(100 - \text{Prediction Response Value}) \times \text{Sub - Cycle Length}}{100}$$

The prediction response value indicates the speed of average heat update. A larger value means faster average heat update and faster predicted demand update (range: 0 – 100).

The initial value of average heat is 0, and iterative calculation is performed every second.

Explanations of each parameter in Formula 3:

- Average heat: Its calculation formulas are shown in Formula 2 and Formula 3.
- Remaining time of demand sub-cycle: The remaining time of the calculation sub-cycle. For example, if the sub-cycle is 5 minutes, the remaining time is 2 minutes when 3 minutes have passed.
- Integral value: The accumulated integral value of the sub-cycle. For example, if the sub-cycle is 5 minutes and 3 minutes have passed, and the demand is power, the integral value should be the energy consumed in the first 3 minutes.
- Previous demand value: The demand calculation value of the previous calculation cycle. Since it is sliding demand, this is the demand value calculated at the end of the previous sub-cycle.

- Number of sub-cycles in the demand cycle: The number of sub-cycles included in one demand cycle.
- Sub-cycle length: The time length of the sub-cycle.

Note: All time-related units involved here must be consistent, and seconds should be used as the unit.

4.4.3 Maximum Demand

The device provides records of the current and previous maximum demand, including the maximum demand value and its occurrence time.

The method of transferring the current maximum demand to the previous maximum demand can be set through the transfer time. After the transfer, the record of the current maximum demand is cleared, and the recording of the maximum demand value is restarted. The transfer time can be set to: End of month.

4.5 Over-Limit Monitoring Function

The fixed-value over-limit system of PMAC780H-Pro can be set via communication through upper computer software or the Web interface. A maximum of 64 groups of over-limit parameters can be set, and each group of parameters includes the following contents:

(1) Trigger mode: Over upper limit / Over lower limit

(2) Monitoring objects:

Table 4-5 Fixed-Value Over-Limit Monitoring Parameters

Type	Over-Limit Monitoring Objects
Standard	L1 Phase Voltage, L2 Phase Voltage, L3 Phase Voltage, L4 Phase Voltage, L1 Phase Current, L2 Phase Current, L3 Phase Current, L4 Phase Current, Phase Voltage, Phase Current, Line Voltage, Average Line Voltage, Average Phase Voltage, Average Current, Total Active Power, Total Reactive Power, Total Apparent Power, Total Power Factor, Positive Sequence Voltage, Negative Sequence Voltage, Zero Sequence Voltage, Positive Sequence Current, Negative Sequence Current, Zero Sequence Current,

	Negative Sequence Voltage Unbalance, Zero Sequence Voltage Unbalance, Negative Sequence Current Unbalance, Zero Sequence Current Unbalance, Frequency Deviation, Frequency, Upper Voltage Deviation, Lower Voltage Deviation, Short-Term Flicker, Long-Term Flicker, Real-Time Demand of Total Active Power, Real-Time Demand of Total Reactive Power, Real-Time Demand of Total Power Factor, Predicted Demand of Total Active Power, Predicted Demand of Total Reactive Power, Predicted Demand of Total Power Factor, Fundamental Voltage, Fundamental Current, Total Voltage Harmonic Distortion Rate, Total Odd Voltage Harmonic Distortion Rate, Total Even Voltage Harmonic Distortion Rate, Total Current Harmonic Distortion Rate, Total Odd Current Harmonic Distortion Rate, Total Even Current Harmonic Distortion Rate, Total Voltage Interharmonic Distortion Rate, Total Current Interharmonic Distortion Rate, Total Voltage Harmonic Distortion Rate of Any Order, Total Current Harmonic Distortion Rate of Any Order, Voltage Harmonic Content Rate (2nd~63rd), Current Harmonic Content Rate (2nd~63rd), Voltage Interharmonic Content Rate (2nd~63rd), Current Interharmonic Content Rate (2nd~63rd)

(3) Action upper limit / Action lower limit: The action value and return value for triggering over-limit.

- For over upper limit: The monitoring object acts when its measured value exceeds the action value and the duration exceeds the action delay; it returns from over-limit when the measured value is less than the return value and the duration exceeds the return delay.
- For over lower limit: The monitoring object acts when its measured value is less than the action value and the duration exceeds the action delay; it returns from over-limit when the measured value is greater than the return value and the duration exceeds the return delay.

(4) Action delay: The delay time before action is triggered after over-limit is detected. For standard over-limit, the action delay can be set within 0 – 999 seconds.

(5) Return delay: The delay time before returning from over-limit. For standard over-limit, the return delay can be set within 0 – 999 seconds.

(6) Trigger type: Over-limit trigger action

All over-limit actions will generate SOE (Sequence of Events) records, and trigger outputs can be set. The output actions include RO/DO output, waveform recording, and real-time quantity recording.

The trigger mode of fixed-value over-limit can be set to over upper limit or over lower limit. The judgment logic for over upper limit and over lower limit is explained as follows:

Figure 24 describes the scenario of over upper limit, taking the over-limit triggering relay action as an example. When the measured parameter exceeds the action upper limit and the duration exceeds the action delay, the over-limit triggers the relay to act; when the measured parameter is less than the action lower limit and the duration exceeds the return delay, the relay returns.

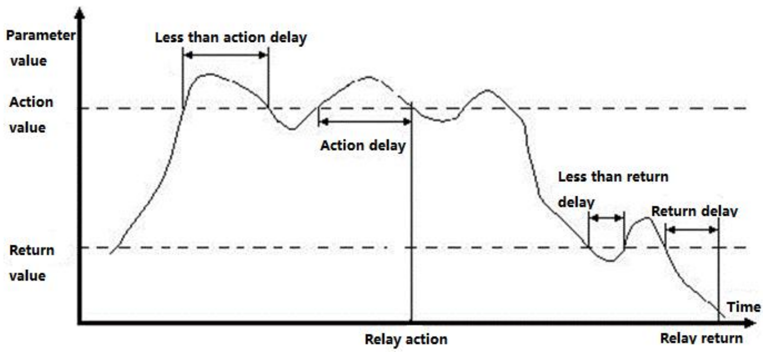


Figure 26 Over Upper Limit

Figure 25 describes the scenario of over lower limit, taking the triggering of relay action as an example. When the measured parameter is lower than the action lower limit and the duration exceeds the action delay, the over-limit triggers the relay to act; when the measured parameter is higher than the action upper limit and the duration exceeds the return delay, the relay returns.

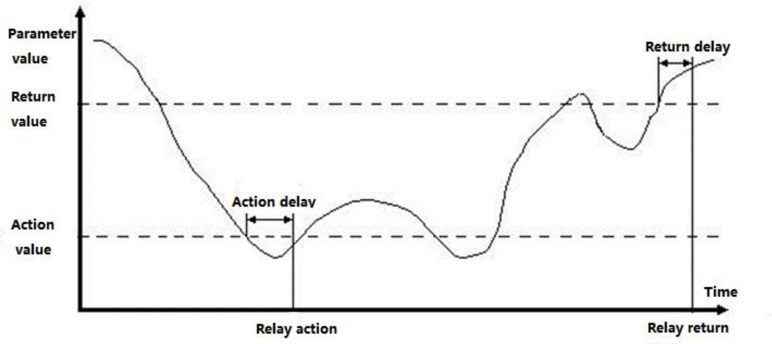


Figure 27 Over Lower Limit

4.6 Time-of-Use (TOU) Tariff Function

PMAC780H-Pro has two sets of tariff schemes, and each set includes time zone setting, daily time period table setting, and special day setting. In power systems, electricity prices may differ between working days, weekends, and holidays, as well as between peak and off-peak load periods. This function is an energy metering method designed to adapt to peak-valley time-of-use electricity prices. It can calculate and accumulate the energy under each time-of-use tariff according to pre-set billing time periods and tariffs to realize time-sharing metering.

In the TOU function, the time setting is based on an annual cycle. Ordinary days and special days can be set each year, with a maximum of 90 special days. A maximum of 12 time zones can be set in a year; a week can be divided into 4 types: working day / rest day 1 / rest day 2 / rest day 3, and the corresponding daily time period table number can be set for each type. A maximum of 20 daily time period tables can be set, and each table divides 24 hours a day into a maximum of 16 time periods, with each time period corresponding to a unique tariff (a maximum of 8 tariffs can be set). For holidays that require separate settings, this can be achieved by setting the special day register to specify the date of the special day and the corresponding daily time period table.

The two sets of schemes can be set independently for TOU tariffs, and automatic switching between the two sets of schemes can be realized by setting the switching date.

The TOU tariff function can realize time-sharing metering of forward/reverse active energy/reactive energy, as well as total active energy, total reactive energy, and total apparent energy. The maximum energy value for each tariff period is 999999999.999 kWh.

Parameter ranges are as follows:

- Billing time zones: 1 – 12 time zones. The start time of Time Zone 1 is January 1st and cannot be modified. If a date is set to 0xFFFF or another non-existent date, it is considered an invalid date. If the date of a certain time zone in the time zone scheme is set to 0xFFFF, all subsequent dates after this time zone should be set to 0xFFFF. The setting rule for the time zone scheme is: The date of the latter time zone should be later than that of the previous one, unless all subsequent time zones are set to 0xFFFF.
- Billing day types: 4 types (working day / rest day 1 / rest day 2 / rest day 3), and daily time period tables can be set separately for each type.
- Daily time period tables: A maximum of 20 time period tables. Each table can set a maximum of 16 time periods, with the minimum time unit of each time period being 15 minutes. If the value is 0, it indicates that within the current time zone, Daily Time Period Table 1 is used, and its valid time is from the start date of the current time zone to the start date of the next time zone. If the start date of the next time zone is set to 0xFFFF, its valid time is from the start date of the current time zone to the end of the year. For each daily time period table, the setting rule for time periods is: The time of the latter time period should be later than that of the previous one, unless all subsequent time periods are set to 0xFFFF.
- Special days: 0 – 90 special days. A separate daily time period table can be specified for each special day.
- Tariffs: 8 tariffs.

This function can be set via communication or the Web interface.

4.7 Waveform Recording Function

After configuring the waveform recording function of PMAC780H-Pro device, it can be activated when over-limit, voltage swell/sag/interruption, transient disturbance, rapid voltage change, inrush current, sudden change, or DI (Digital Input) state change occurs. It records the waveforms of three-phase voltage, three-phase current, neutral line current, and neutral line voltage simultaneously.

In addition, waveform recording can also be triggered by communication or scheduled recording.

The number of sampling points can be set from 128 points per cycle to 1024 points per cycle, and the number of cycles is matched accordingly. The recorded waveforms are stored in the system files in COMTRADE format, which is non-volatile (not lost when power is off).

Setting parameters:

- Recording mode setting: The device provides the following setting modes: 1024 points/cycle @ 200 cycles, 512 points/cycle @ 400 cycles, 256 points/cycle @ 800 cycles, and 128 points/cycle @ 1600 cycles. For example, setting to the mode of 1024 points/cycle @ 200 cycles means that the recording mode for this group is 1024 points recorded per cycle, with a recording length of 200 cycles.
- Number of pre-fault cycles: The number of pre-fault cycles can be set, with a setting range of 2﹣16.
- Number of waveform records: A maximum of 256 records.

4.8 Real-Time Quantity Scheduled Recording Function

The device can provide a scheduled recording function for real-time quantities, which automatically records the configured real-time measurement 1-second values at set intervals. It can be used for automatic scheduled meter reading, load trend analysis, dynamic stability analysis of power systems, etc.

There are 8 groups of real-time quantity scheduled recording, and each group operates independently. Users can set different parameters for recording according to needs. The real-time quantity scheduled recording can be set to start continuous recording directly, or set to trigger-based start (triggered by over-limit events, power quality fault events, or DI) to record the changes in real-time quantity data during the occurrence of over-limit, power quality faults, and DI linkage events.

Each group of real-time quantity scheduled recording can record a maximum of 65535 data entries, and each entry is marked with date and time and stored in non-volatile memory (not lost when power is off). The real-time quantity scheduled recording supports two recording modes: cyclic recording and stop-when-full. For cyclic recording, after the set number of entries is full, new records are still generated and overwrite the oldest records cyclically; for stop-when-full, recording stops after 65535 entries are recorded.

4.9 Maximum/Minimum Value Recording Function

The device can record the maximum and minimum values of real-time measured values, including the maximum/minimum data and their occurrence times.

The following quantities' maximum and minimum values are recorded:

- Three-phase current
- Three-phase phase voltage and average phase voltage
- Three-phase line voltage and average line voltage
- Neutral line current and neutral line voltage
- Three-phase active power / three-phase reactive power / three-phase apparent power
- Total active power / total reactive power / total apparent power
- Three-phase power factor
- Total power factor
- Frequency
- Total harmonic distortion rate of three-phase voltage and neutral line voltage
- Total harmonic distortion rate of three-phase current and neutral line current
- Total interharmonic distortion rate of three-phase voltage and neutral

line voltage

- Total interharmonic distortion rate of three-phase current and neutral line current
- Current K-factor of three-phase current and neutral line current
- Current TDD (Total Demand Distortion) of three-phase current and neutral line current
- Voltage negative sequence and voltage zero sequence
- Current crest factor of three-phase current and neutral line current
- Voltage crest factor of three-phase voltage and neutral line voltage
- Three-phase short-term flicker and long-term flicker
- The first group of signal voltage of three-phase voltage
- The second group of signal voltage of three-phase voltage
- The third group of signal voltage of three-phase voltage

4.10 Monitoring Events

Monitoring events include PQ events and SOE events, with each type capable of recording up to 2048 entries, which are non-volatile during power outages. PQ events cover transient disturbances, instantaneous perturbations, rapid fluctuations, inrush currents, etc. SOE events include switch position changes, relay outputs, over-limits, etc. The recorded content of events includes event type, occurrence time, characteristic values, etc. The time resolution is 1ms.

After a monitoring event is generated, a pop-up window will display the event on the LCD interface. All monitoring events can be read via communication or directly viewed on the Web interface. If the 2048 event records are full, the oldest records will be overwritten first.

Monitoring event records can be cleared via communication or the Web interface.

4.11 Operation Records

Up to 2048 operation records can be stored, which are non-volatile during power outages. If the number exceeds 2048, the oldest records will be overwritten starting from the first one. It mainly records operations such as device power-off, device power-on, and configuration parameter modification. Each operation log includes occurrence time and characteristic values. The time resolution of events is 1ms.

Operation records can be viewed and cleared via communication or the Web interface.

4.12 Digital Input (DI)

Each digital input of the device can be set to realize one of the following two functions according to actual application needs:

(1) General Digital Input

Used to detect the status of external passive contacts or external active contacts.

The real-time status of the digital input can be observed through the LCD display, communication, or Web. Digital input position change events are recorded in SOE with a time resolution of 1ms.

When the DI changes state, the change can trigger relays and wave recording through configuration.

(2) Pulse Counting

Used to receive pulses from electric energy meters or other devices and count them.

When the DI state changes from open to closed, the count changes, and the count value is calculated through the pulse proportional coefficient; no SOE is generated at this time. Each pulse counter can be set with a fixed value and reset.

4.13 Relay Outpot (RO)

The relay provides two control modes: remote control and local control. When set to local control, the relay responds to functions such as over-limit, transient, instantaneous, rapid voltage fluctuation, inrush current, sudden change, and DI state change; when set to remote control, it responds to the closing/opening commands from the upper computer.

Remote Control: Responds to remote control commands for relay opening and closing. In remote control mode, it is not affected by the relay delay time.

Local Mode: When the delay time is set to 0, the fixed-value over-limit action can trigger the relay to act, and the relay returns when the over-limit is restored. When a voltage swell/sag interruption, transient disturbance, or rapid voltage fluctuation triggers the relay to act, the relay returns when the triggering event ends; when the delay time is set to a non-zero value, the relay is triggered to act in case of a fault and returns after the delay time is reached. If only one event occurs (i.e., there is no start and end event), the event triggers the relay to act, and the relay returns after a fixed 100ms.

4.14 Digital Output (DO)

PMAC780H-Pro is equipped with 2 DOs. The function of DO can be configured through the DO output mode parameter, and the DO functions are divided into two types:

Output Function (i.e., all functions of RO, but the breaking capacity of RO and DO is different, and an external intermediate relay is generally required);

Electric Energy Pulse Output Function: Active energy pulse output, reactive energy pulse output.

4.15 Communication Function

PMAC780H-Pro provides 2 RS485 interfaces and 2 Ethernet interfaces.

(1) RS-485 Communication

The RS-485 communication interface supports the MODBUS communication protocol. The baud rate supports optional 1200bps, 2400bps, 4800bps, 9600bps, 19200bps, and 38400bps. The parity bit supports odd parity, even parity, and no parity. The stop bit supports 1 or 2 stop bit settings.

(2) Ethernet Communication

The Ethernet interface adopts a standard RJ-45 interface with an adaptive communication rate of 10M/100M.

a) Supports the MODBUS-TCP communication protocol. The port number can be configured, with the default port number being 502. Each Ethernet interface supports up to 12 MODBUS-TCP connections.

Please refer to the MODBUS communication protocol of PMAC780H-Pro for the specific communication frame format.

b) Supports the IEC 61850 protocol. See the 61850 protocol for specific specifications.

4.16 Time Synchronization Function

The device supports software time synchronization.

Software time synchronization supports NTP network time synchronization and Modbus communication time synchronization. NTP network time synchronization means the device automatically obtains high-precision time from a network time server. Modbus communication time synchronization means the upper computer synchronizes the time of the device through the Modbus protocol.

The device also supports GPS time synchronization in the format of IRIG-B code and PPS time synchronization.

4.17 Storage Function

PMAC780H-Pro has a 32GB eMMC storage capacity, mainly used to store waveform records, SOE records, PQ records, PQDIF, EN50160, scheduled records, configuration files, etc. Waveform data is stored in COMTRADE format, and event record data is stored in the format specified by the protocol.

4.18 Real-Time Waveform

PMAC780H-Pro provides a real-time waveform display function. On the device interface and Web, real-time waveform of 4 cycles can be displayed. Waveform of three-phase current, voltage, neutral line current, and voltage can be displayed.

4.19 GATEWAY Function

PMAC780H-Pro uses the network port and RS-485 to implement a simple communication management machine function. The uplink network port supports the Modbus_TCP protocol, with a default port number of 6000 (which cannot be configured). The gateway forwarding ports correspond as follows: Network Port 1 corresponds to RS4851, and Network Port 2 corresponds to RS4852. The downlink serial port supports the Modbus_RTU protocol. The RS-485 can be configured as the GATEWAY function to collect data from downstream devices.

4.20 Historical Electric Energy

PMAC780H-Pro provides daily historical energy for the latest 62 days, monthly historical energy for the latest 12 months, and annual historical energy for the latest 10 years. Among them, daily, monthly, and annual historical energy store active energy (including input, output, total, and net value), reactive energy (including input, output, total, and net value), apparent energy, four-quadrant reactive energy, and energy at each rate (including input and output).

4.21 FTP Function

PMAC780H-Pro provides an FTP download function. Connect to the host via the FTP protocol (port number 21) and log in anonymously to download. The downloadable data includes wave recording files (COMTRADE format) and PQDIF format files.

4.22 Load Operation Monitoring

For load operation monitoring, one of current, voltage, or total power can be selected for monitoring, and corresponding thresholds can be configured. When the real-time value exceeds the set threshold, the load is considered to be running, and the load running time will be accumulated; otherwise, it is considered to be no load. For voltage and current, the maximum value of the three phases is compared with the threshold.

Load operation monitoring includes parameter statistics such as load running duration, load running times, load power-on duration, meter running duration, meter power-off duration, meter power-off times, last power-off time, and last power-on time of the meter.

The load monitoring object and threshold can be configured through the Web meter parameter column or issued and configured via Modbus.

4.23 Web Service

PMAC780H-Pro supports accessing web pages via HTTP/HTTPS. HTTP uses port 80, and HTTPS uses port 443. It provides admin user access rights and visitor access rights and supports password modification. Parameter setting requires secondary password verification, and the password is the login password of the currently logged-in user.

Note: *Password modification requires a length of 6-12 characters.

Web login accounts are as follows, and the account and password are case-sensitive.

Username	Default Password	Accessible Pages
admin	pmac.100	Meter Functions (All), Power Quality (All), Data Records (All), Parameter Settings (All), My Device Debugging [Device Status, Password Modification, Online Upgrade, Terminal Debugging]
visitor	pmac.001	Meter Functions (All), Power Quality (All), Data Records (All), My Device Debugging [Device Status, Password Modification]

Accessing the Web Interface: Connect the device to the computer that needs to access the device's Web interface via a network cable, or connect the device to the local area network. Set the IP addresses of the device and the computer to be in the same network segment. Then open a browser on the computer, enter the device's IP address in the address bar to enter PMAC780H-Pro Web login interface. Enter the account and password to log in and use the Web service.

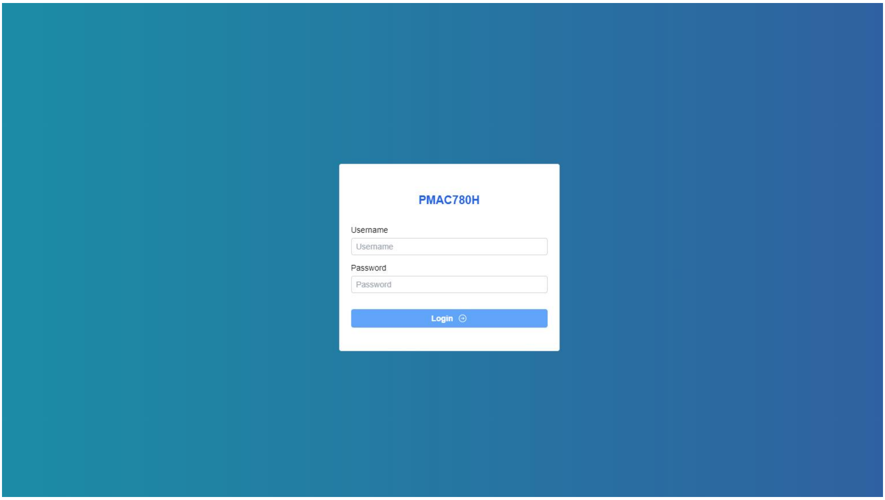


Figure 28 Web Service Login

Chapter 5 Display and Settings

PMAC780H-Pro adopts a TFT color LCD screen with a resolution of 640×480, featuring convenient and simple operation.

5.1 Keys

PMAC780H-Pro is designed with 6 keys: 4 direction keys(Up, Down, Left, Right), an OK , and an Exit . The functions of each ksy are as follows:

Key	Function
↩	Exit to the previous menu; Or cancel the input value.
<	Move the cursor to the left; Or page left.
∧	Move the cursor upward; Or add 1 to the number where the cursor is located.
∨	Move the cursor down; Or the number where the cursor is located minus 1.
>	Move the cursor to the right; Or turn pages to the right
↵	Enter the next menu; Or confirm the input value.

5.2 Indicators

PMAC780H-Pro has three indicators: Run Indicator, Communication Indicator, and Fault Indicator.

Indicator	Function
	Indicates the running state of the device, and flashes regularly when the device is normal.
	Indicates the status of serial communication, and flashes when there is serial communication.
	Indicates the alarm status, and is currently associated with the over-limit alarm function.

5.3 Settings and Display

When the device is powered on, it initializes. After successful initialization, it enters the main interface, which is divided into 4 menus: Meter Measurement, Power Quality, Event Record, and Parameter Setting.

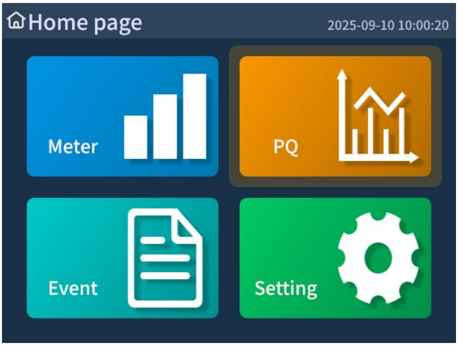


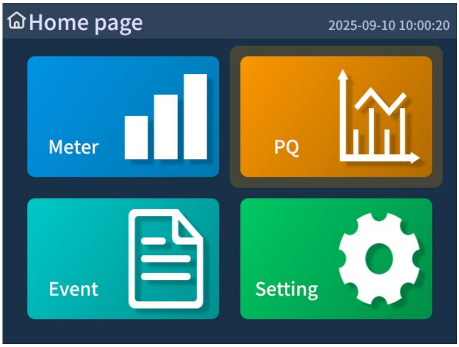
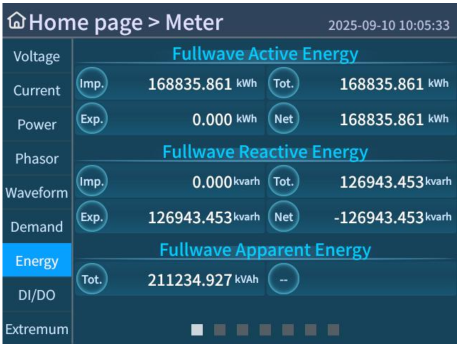
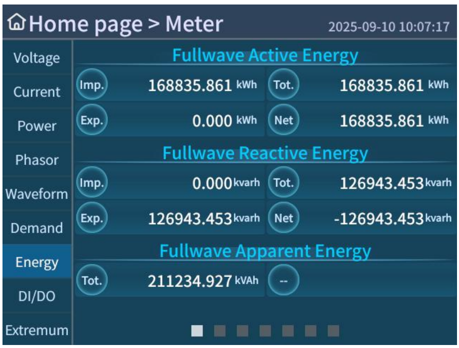
Figure 29 Main

5.3.1 Meter Measurement

On the main interface, press the " ∧ "," ∨ "," < "," > "to move the cursor, select the "Meter Measurement" menu, and press the " ↩ " to enter the Meter Measurement menu interface. The interface includes 9 sub-interfaces: Voltage, Current, Power, Phase Diagram, Waveform Diagram, Demand, Energy, Switch Status, and Maximum/Minimum Values. Press the " ∧ "," ∨ "switch between different functions in the left menu bar, and the menu bar will switch cyclically.

In the Meter Measurement interface, some function interfaces support paging or checking the data to be viewed. Specific button operation instructions: In the Meter Measurement interface, press the" ∧ "," ∨ "to switch between different functions in the menu bar. When paging is needed, press the" ↩ "to select (press the" ⮌ "to cancel the selection). After selection, the color of the menu bar will change, and press the" < "," > "to page. For data checking, press the" < "," > "to switch the cursor position, and press the" ↩ "to select.

Example of viewing the Energy Data interface:

<table>
<tr>
<td>In the main interface, after the cursor selects the "Meter Measurement" menu, press" ↩ "to enter the Meter Measurement interface.</td>
<td>
</td>
</tr>
<tr>
<td>In the Meter Measurement interface, press " ∨ "to switch the menu bar to "Energy".</td>
<td>
</td>
</tr>
<tr>
<td>In the Energy interface, press" ↩ "to select, and the color of the menu bar will change.</td>
<td>
</td>
</tr>
</table>

Press" < "or" > "to switch pages. Press " ↩ " to return to the left menu.	

Note:The operation of other measurement pages is similar, and the operation method can be inferred accordingly.

5.3.2 Power Quality

The Power Quality page includes 10 sub-pages: Harmonic Value, Harmonic Diagram, Interharmonic Value, Interharmonic Diagram, Deviation, Unbalance, Flicker, Signal Voltage, ITIC Curve, and SEMI F47 Curve. Press " ∧ "or" ∨ " to switch between these sub-pages.

Figure 30 Power Quality Main

5.3.3 Event Record

The Event Record page enables viewing of all monitored events, including Power Quality (PQ) events and Sequence of Events (SOE) events. Press

" "to enter the event interface, use the " "or" " to scroll through events, and press" " to select whether the event switching is by one line, one page or ten pages.

Figure 31 Event Record

When an event record (PQ event or SOE event) is generated, a pop-up window will appear on the LCD screen.Press the " "or " "to close the pop-up window, as shown in the following figure:

Figure 32 Event pop-up display

5.3.4 Parameter Setting

To access the Parameter Setting interface from the main menu, a valid user password must be entered. The default factory password is "1".

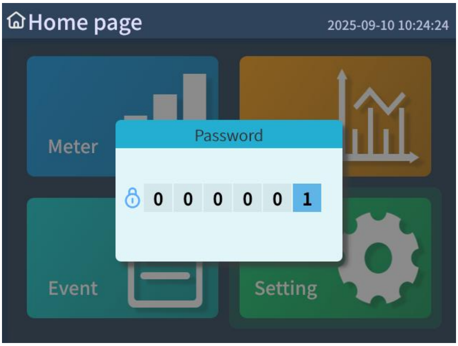
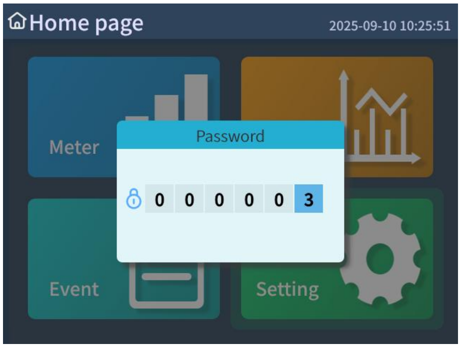
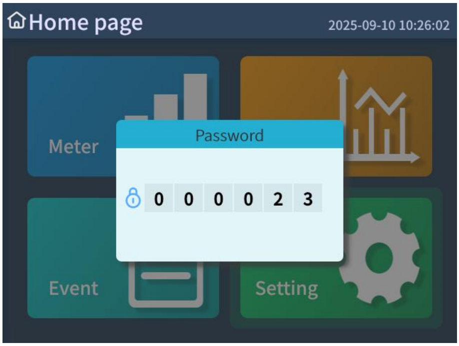
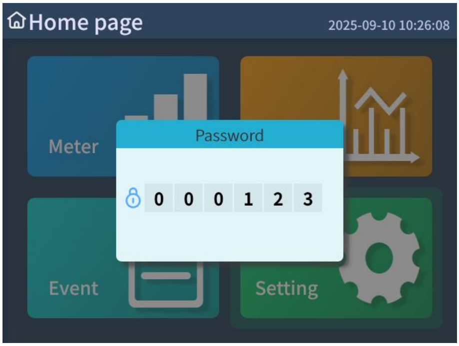
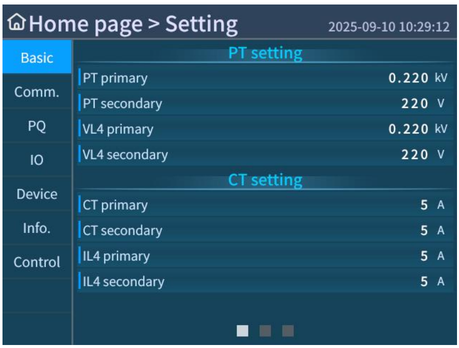


Figure 33 Password Input

Example of Password Input Operation (assuming the user password is 123):

When entering the password input interface, the cursor blinks at the units place. Press " ∧ "or" ∨ "to increase or decrease the number at the blinking cursor position, Enter "3" for the units place.	

<table>
<tr>
<td>Press " < "to move the cursor to the tens place, then press" ∧ " to enter "2".</td>
<td>
</td>
</tr>
<tr>
<td>Press " < "to move the cursor to the hundreds place, then press " ∧ " to enter "1".</td>
<td>
</td>
</tr>
<tr>
<td>After entering the correct password, press " ↵ " to access the Parameter Setting interface.</td>
<td>
</td>
</tr>
</table>

5.3.4.1 Basic Setting

The Basic Setting page includes PT/CT Setting, Demand/Connection, and

Rated Parameter Setting pages.

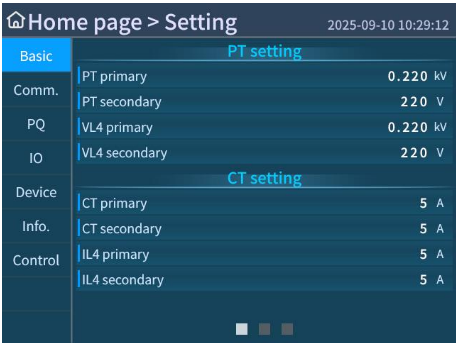


Figure 34 PT/CT Setting

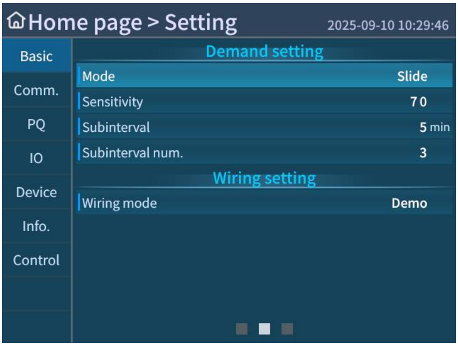


Figure 35 Demand/wiring setting

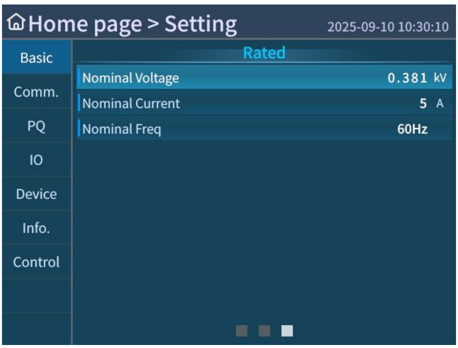


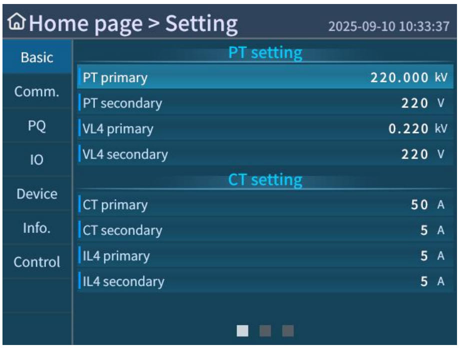
Figure 36 Rated parameter setting

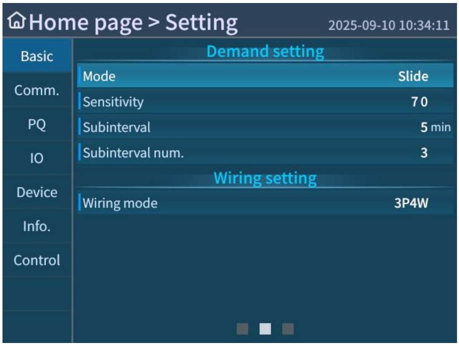
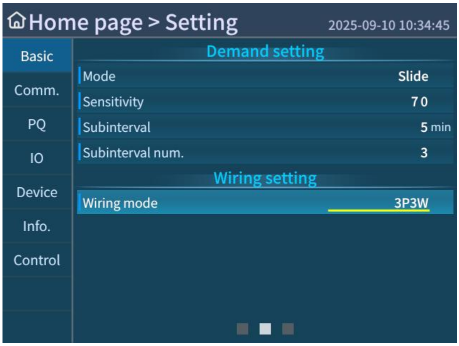
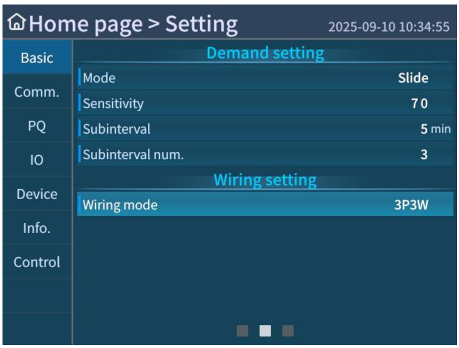
Basic Parameter Setting Table:

Setting Parameter	Default	Setting Range
PT Primary Side	0.220	0.001-9999
PT Secondary Side	220	1-999
CT Primary Side	5	1-50000
CT Secondary Side	5	1-50
U4 Primary Side	0.220	0.001-9999
U4 Secondary Side	220	1-999
I4 Primary Side	5	1-50000
I4 Secondary Side	5	1-50
Demand Mode	Sliding	Fixed / Sliding
Sensitivity	70	70-99
Demand Sub-period	5	1-60
Number of Sub-periods	3	1-15
Wiring Mode	Star	Star / Delta / Demo
Rated Voltage	0.381kV	0.001kV~1.2kV
Rated Current	5A	5A/1A
Rated Frequency	50Hz	50Hz/60Hz

Example of Modifying Wiring Mode:

Select the Basic Setting interface as right.



<table>
<tr>
<td>Press " > " to switch to the Demand/Wiring Setting interface.</td>
<td>
</td>
</tr>
<tr>
<td>Press " ∨ " to move the cursor to the Wiring Mode menu, then press the " ↵ " to select it. Once selected, the content blinks with a yellow underline. Press " ∧ " or " ∨ "to switch between options.</td>
<td>
</td>
</tr>
<tr>
<td>Press " ↵ " to confirm and save the setting.</td>
<td>
</td>
</tr>
</table>

5.3.4.2 Communication Setting

The Communication Setting page includes three submenus: RS485

Setting, Ethernet Setting (each port supports up to 12 client connections), and Protocol Setting. The setting method is consistent with the above operations.

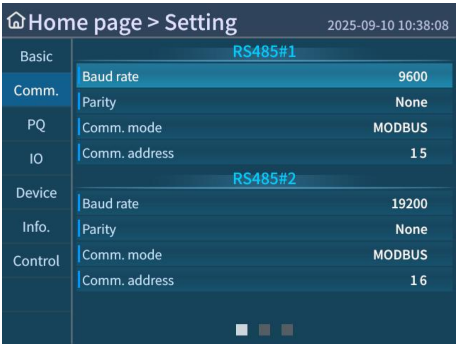


Figure 37 RS485 Setting

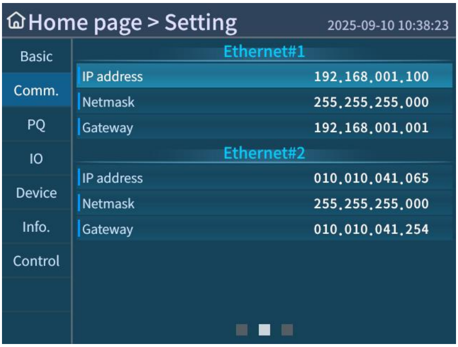


Figure 38 Ethernet Setting

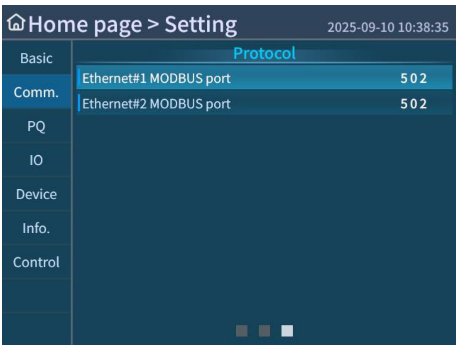


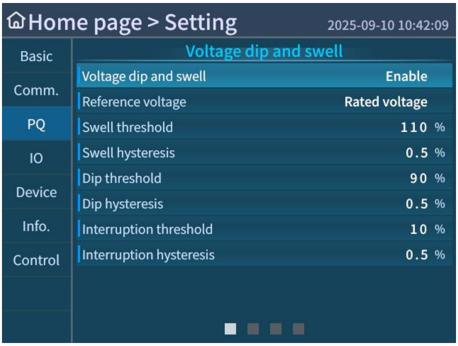
Figure 39 Protocol Setting

Communication Parameter Setting Table:

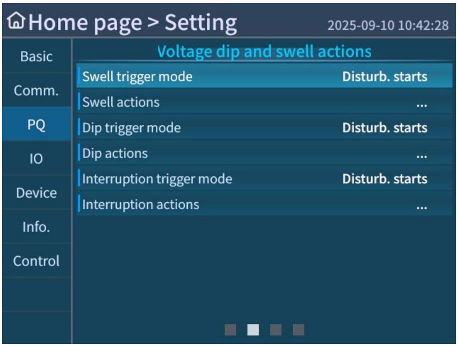
Setting Parameter	Default	Range
RS485 Setting		
Mode	MODBUS-RTU	MODBUS-RTU/Gateway
Device Address	1	1 - 247 (Unique ID required per device on the same link)
Baud Rate	9600	1200/2400/4800/9600/19200/38400bps
Parity Bit	None	Odd / Even / None
Ethernet Setting		
IP	Ethernet#1:192.168.1.100 Ethernet#2:192.168.10.100	Complies with network specifications
Subnet Mask	255.255.255.0	Port 1 and Port 2 cannot be in the same segment
Gateway Address	Ethernet#1:192.168.1.1 Ethernet#2:192.168.10.1	Complies with network specifications
Protocol Setting		
MODBUS Port Number	Ethernet#1:502 Ethernet#2:502	1-65535

5.3.4.3 PQ Setting Interface

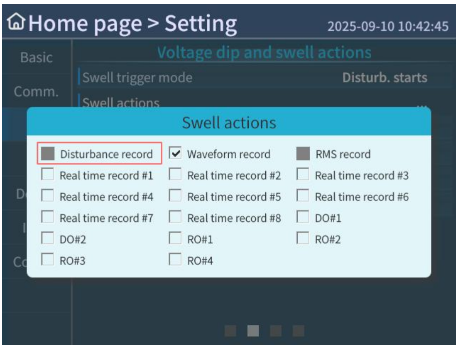
The PQ Parameter Setting interface includes: Voltage Sag/Swell, Voltage Sag/Swell Action, Transient Voltage, and Rapid Voltage Change.



Voltage Swell and Sag



Voltage Swell and Sag Action

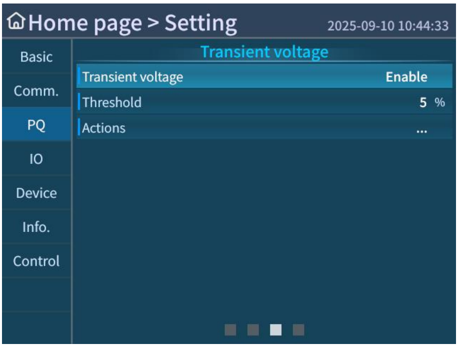


Action-Selectable

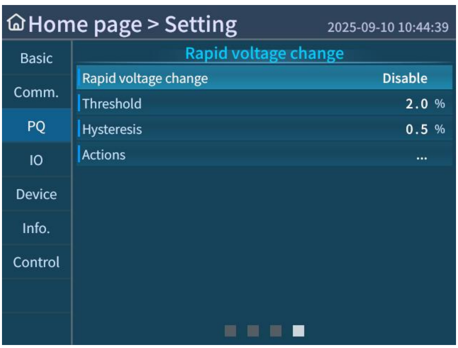
Transient Parameter Setting Table:

Setting Parameter	Default	Setting Range

Transient On/Off		Off	On / Off
Reference Voltage		Rated Voltage	Rolling Reference / Rated Voltage
Trigger Action		None	None / Waveform Record / Real-time Record / DO
Voltage Sag	Threshold	90%	1%-99%
	Hysteresis	0.5%	0.1-100%
Voltage Swell	Threshold	110%	110%-200%
	Hysteresis	0.5%	0.1-100%
Voltage Interruption	Threshold	10%	0-50%
	Hysteresis	0.5%	0.1-100%



Transient Voltage



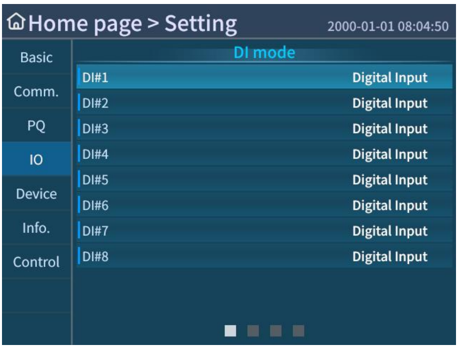
Fast Voltage Variations

Transient/Rapid Voltage Change Parameter Setting Table:

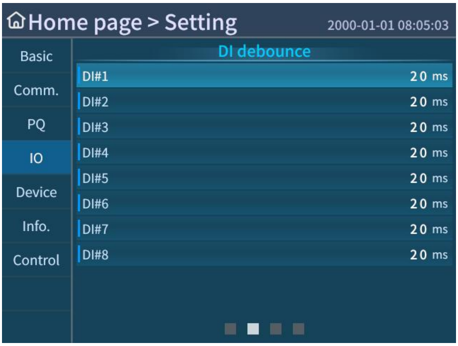
Setting Parameter		Default	Setting Range
Transient	Transient On/Off	Off	On/Off
	Threshold	50%	5%-500%
	Trigger Action	None	None / Waveform Record / DO
Rapid Voltage Change	Rapid Voltage Change	Off	On/Off
	Threshold	0.2%	0%-10%
	Hysteresis	0.1%	0%-5%
	Trigger Action	None	None / Waveform Record / DO

5.3.4.4 IO Setting

The IO Setting interface includes: DI Mode, DI Delay, RO Parameters, and DO Parameters.



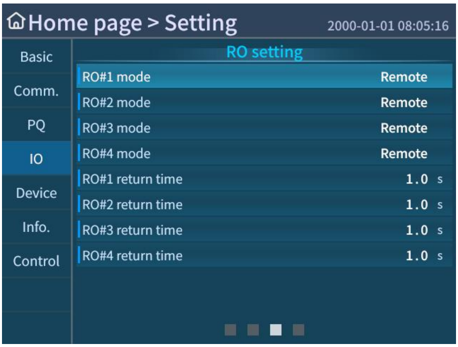
DI Mode



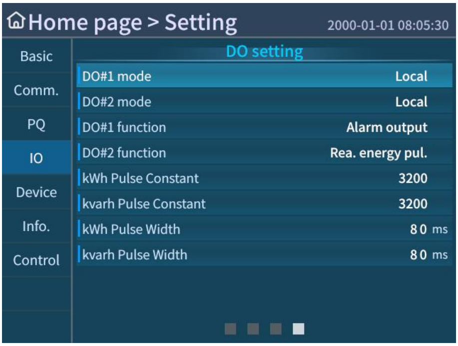
DI Debounce Time

DI Parameter Setting Table:

Setting Parameter		Default	Setting Range
DI-1~DI-8	Mode	DC Digital	General Digital / Pulse Counting
	Delay	20ms	1 - 9999ms (for General Digital mode)



RO Setting



DO Setting

RO/DO Parameter Setting Table:

Setting Parameter		**Default**	**Setting Range**
RO1~RO4	Reset Time	1.0s	0 - 600s (0 = Hold)
	Mode	Local Control	Local Control / Remote Control
DO1~DO2	Mode	Local Control	Local Control / Remote Control
	Function	DO1: Active Energy Pulse DO2: Alarm Output	Active Energy Pulse / Reactive Energy Pulse / Alarm Output
	Pulse Constant	3200	100,1000,3200,5000,6400,12800 pulse/kWh
	Pulse Width	80ms	60-100ms

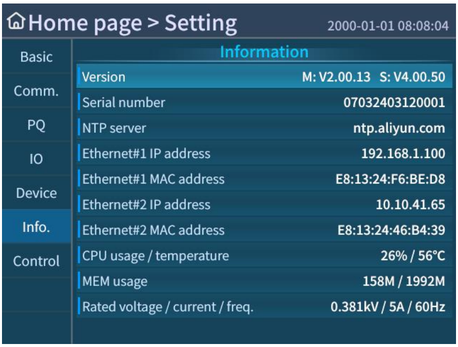
5.3.4.5 Device Parameter Setting

In the Device Setting interface, you can set the device's date, time, time zone, language, backlight duration, and user password. Setting the backlight duration to 0 means the LCD remains on continuously.

Device Setting

5.3.4.6 Information

In the Information interface, you can view the device's version information, serial number, network address, CPU usage, etc.



Information

5.3.4.7 Control

In the Control Setting interface, you can clear real-time energy, clear historical energy, clear monitoring events, clear maximum demand, clear all max/min records, clear all DI pulse counts, clear monitoring event counts, clear EN50160 data, clear all scheduled records, and restart the device. The password "7788" is required for access.

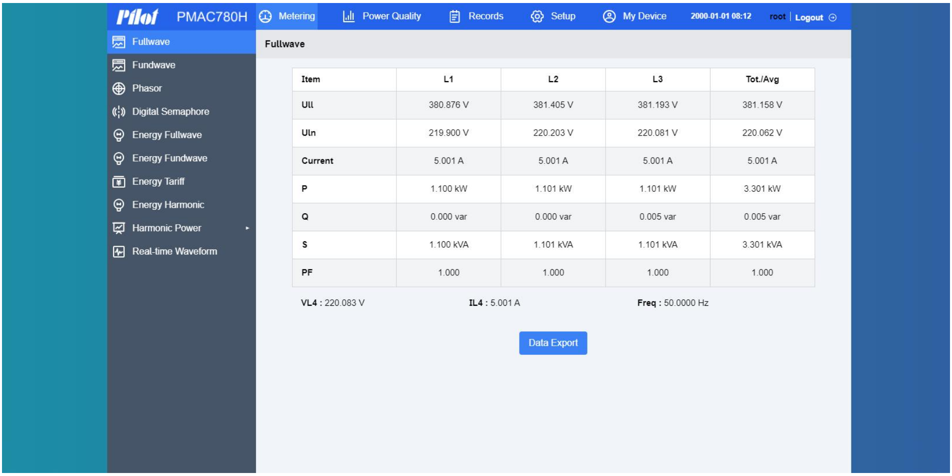
Control

5.4 Web Interface Setting and Display

The Web service provides 5 main functions: Meter Function, Power Quality, Data Record, Parameter Setting, and Device Debugging. After logging in, you enter the Meter Function interface.

Meter Function

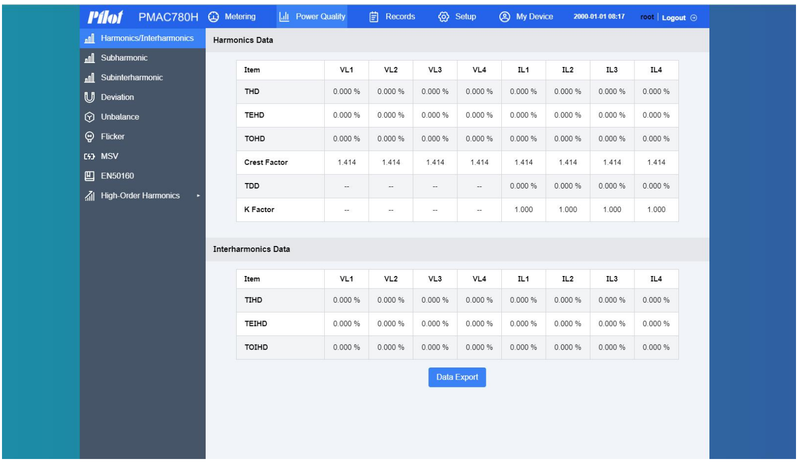
Displays full-wave data, fundamental wave data, fundamental wave vector diagram, digital signals, full-wave energy, fundamental wave energy, time-of-use tariff energy, harmonic energy, and harmonic power (divided into 4 interfaces: Phase A, Phase B, Phase C, and Total Harmonic Power; CH1 corresponds to Phase A, CH2 to Phase B, CH3 to Phase C), and real-time waveforms. Users can access different interfaces to view data as needed.



Metering

Power Quality

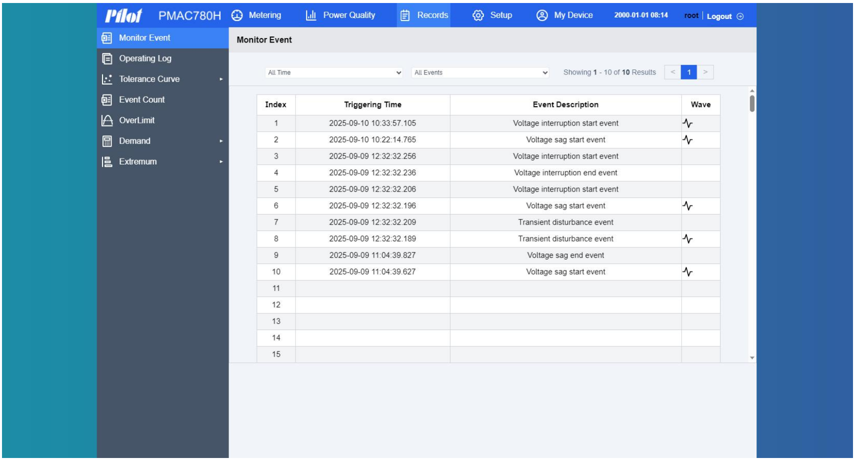
Allows viewing of harmonic and interharmonic measurement data, harmonic by order, interharmonic by order, positive/negative deviation, unbalance, flicker, signal voltage, and EN50160 data.



Power Quality

Data Records

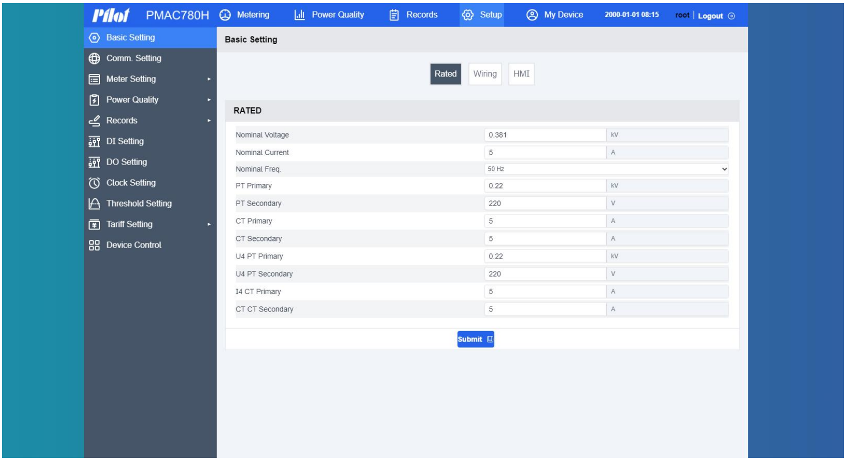
Enables viewing of monitoring events, operation records, tolerance curves (ITIC and SEMI-F47), event counts, demand statistics (real-time demand, last demand max/min), and max/min statistics (divided into 4 groups, each group allows viewing current and last max/min values).



Records

Parameter Setting

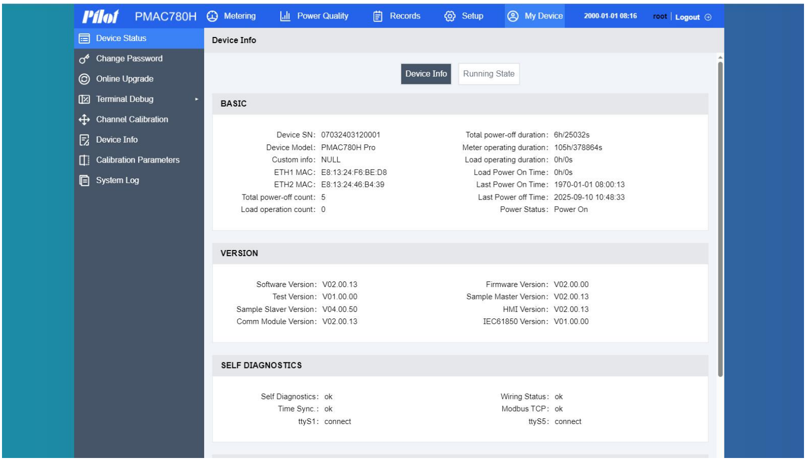
Includes Basic Setting (rated parameters, wiring parameters, HMI setting), Communication Setting (Ethernet, RS-485, protocol parameters, communication service setting), Meter Parameter (demand, energy base value, algorithm and other settings), Power Quality (monitoring items, EN50160; monitoring items allow setting parameters related to transient voltage, transient voltage, rapid voltage change, signal voltage, inrush current, variation, harmonics, and flicker; EN50160 allows setting related parameters), Record Setting (waveform parameters, max/min records, real-time scheduled records), DI Setting, DO Setting, Clock Setting, Over-limit Setting, Time-of-Use Tariff Parameter Setting, and Device Maintenance (device information, device control; device control allows parameter maintenance, device restart, DO/RO control, and data clearing).



Setup

My Device

Includes: Device Status, Password Modification, Online Upgrade, and Terminal Debugging [analog value setting, DI setting, DO setting].



My Device

Chapter 6 Technical Indicators

6.1 Instrument Parameters

PMAC780H-Pro complies with the national standard IEC61000-4-30 Electromagnetic compatibility (EMC) Part 4-30: Testing and measurement techniques Power quality measurement methods。

Specific indicators and display methods of parameters are shown in the following table:

Measuring Parameter		显示	通讯	精度
Power Quality				
Voltage Fast Fluctuation	Voltage	Event	Event	
Voltage Deviation	Voltage	Percentage	Percentage	±0.1%
Frequency Deviation	Frequency	Deviation Value	Deviation Value	±0.003Hz
Transient Overvoltage	Voltage	Event	Event	20μs,1400V
Unbalance Rate	Voltage, Current	Percentage	Percentage	Class A
HR	63rd Voltage/Current Harmonic Component	Percentage	Percentage	Class A
Harmonic Effective Value	63rd Voltage/Current Harmonic Component	Primary Side Value	Primary Side Value	Class A
Inter-harmonic Effective Value	63rd Voltage/Current Inter-harmonic	Primary Side Value	Primary Side Value	Class A

	Component			
High-order Harmonic Effective Value	2k~9k Harmonic	Primary Side Value	Primary Side Value	Class A
Harmonic Distortion	Total/Odd/Even Harmonic Distortion Rate	Percentage	Percentage	Class A
Inter-harmonic Distortion	Total Inter-harmonic Distortion Rate	Percentage	Percentage	Class A
Flicker	Voltage	-	-	±5%
Harmonic Phase Angle	Voltage, Current	-	-	±1°
Real-time Parameter Effective Value				
Voltage	Phase Voltage/Line Voltage/Average Value	Primary Side Value	Primary Side Value	±0.1%
Current	Phase Current/Zero-sequence Current/Average Value	Primary Side Value	Primary Side Value	±0.1%
Active Power	Single-phase/Total	Primary Side Value	Primary Side Value	±0.2%
Reactive Power	Single-phase/Total	Primary Side Value	Primary Side Value	±0.2%
Apparent Power	Single-phase/Total	Primary Side Value	Primary Side Value	±0.2%
Power Factor	Single-phase/Total	Primary Side Value	Primary Side Value	±0.2%
Active Energy	Single-phase, Input, Output, Total	Primary Side Value	Primary Side Value	Class 0.2S

Reactive Energy	Single-phase, Input, Output, Total	Primary Side Value	Primary Side Value	Class 0.5
Maximum/Minimum Value	Phase Voltage/Current; Total Active/Total Reactive Power	Primary Side Value	Primary Side Value	—
Demand	Three-phase Current; Total Active/Total Reactive/Total Apparent Power	Primary Side Value	Secondary Side Value	—
Time-of-use Tariff	Input and Output	Primary Side Value	Primary Side Value	—
Frequency	Frequency	-	-	±0.003Hz
Function	**Description**			
Communication	2 RS485 ports, 2 Ethernet ports, 1 USB2.0 interface			
Relay Output	4 normally open relays configured			
Digital Input	8 external passive or 8 external active digital inputs provided			
Pulse Output	2 pulse outputs provided, configurable as active energy and reactive energy output (secondary side full-wave energy pulse)			
Storage	Maximum 32GB internal instrument storage			
Clock	Instrument local clock: 0.5s/day			

6.2 Performance Indicators

	Parameter	**Range**
Rated Parameters	Operating Power Supply	AC85~275V, DC100~300V, DC24~48V
	Total Power Consumption	＜10VA
	Overload Capacity	Voltage: 2x continuous, 4x/1s; Current: 4x continuous, 10x/1s

	Rated Voltage for Digital Input	DC110V/220V±20% or external passive (30V DC provided internally)	
	Rated Contact Capacity of Relay Output	AC250V/5A, DC30V/5A	
	DO output capacity	Max. voltage:36VDC Max. current:50mA	
	Parameter	**Performance**	
Insulation Performance	Power Frequency Withstand Voltage	AC2kV/Min~1mA (Input-Output-Power Supply)	
	Insulation Resistance	＞50MΩ	
	Impulse Voltage	6kV (peak), 1.2/50μs	
	Parameter	Performance	
Safety performance	OVC	III	
	CAT	III	
	Item	**Reference Standard**	**Test Level**
EMC	Electrostatic Discharge Immunity	GB/T17626.2-2006 (IEC61000-4-2:2001)	Level 4
	Radio-frequency Electromagnetic Field Radiation Immunity	GB/T17626.3-2006 (IEC61000-4-3:2002)	Level 3
	Electrical Fast Transient/Burst Immunity	GB/T17626.4-2008 (IEC61000-4-4:2004)	Level 4
	Surge (Impulse) Immunity	GB/T17626.5-2008 (IEC61000-4-5:2005)	Level 4
	Immunity to Conducted Disturbances Induced by	GB/T17626.6-2008 (IEC61000-4-6:2006)	Level 3

	Radio-frequency Fields		
	Power Frequency Magnetic Field Immunity	GB/T17626.8-2006 (IEC61000-4-8:2001)	Level 4
	Voltage Dips, Short Interruptions Immunity	GB/T17626.11-2008 (IEC61000-4-11:2004)	Compliant
	Electromagnetic Disturbance Limits	GB 4824-2013 (CISPR11:2010)	Compliant

Chapter 7 Maintenance and Troubleshooting

Possible Problem	Possible Cause	Possible Solution
No display after control power is applied	Power not supplied to the device	Check if correct operating voltage is applied to L/+ and N/- terminals of the device Check if the control power fuse is blown
Incorrect or unexpected measurement values	Incorrect voltage measurement	Check if neutral point connection is reliable Check if measured voltage matches the device's rated parameters Check if PT setting is correct
	Incorrect current measurement	Check if measured current matches the device's rated parameters Check if CT setting is correct
	Incorrect power measurement	Check if measurement mode setting is correct Check if voltage and current phase sequence match correctly Check if current homonymous terminal is correct
No change in digital input status	Incorrect digital input action voltage	Check if external node type matches the device's rated parameters Check if external wiring is correct
Relay not operating	No control command received	Check if communication link is correct
	Incorrect relay working mode	Check if the current relay is in the correct mode

Upper computer cannot communicate with the device	Incorrect device communication address	Check if device address is consistent with the definition
	Incorrect device communication rate	Check if device communication rate is consistent with the definition
	No terminal resistor on communication link	Check if 120Ω resistor is installed
	Communication link disturbed	Check if communication shielding layer is properly grounded
	Communication line broken	Check if communication cable is disconnected
Unable to access Web	Communication link disconnected	Check if the device's network port light is blinking; verify if the accessing device and instrument are on the same network segment

Notice:

- PILOT reserves the right to modify this manual without prior notice in view of continued improvement.
- Email: marketing@pmac.com.cn

ZHUHAI PILOT TECHNOLOGY CO., LTD.

Add: No. 15, Keji 6 Road, ChuangxinHaian, Tangjia High-tech Zone, Zhuhai, Guangdong, 519085 China

Tel:+86-756-3629688

Fax: +86-756-3629700

http://en.pmac.com.cn